`

REPUBLIC OF IRAQ

MINISTRY OF HIGHER EDUCATION

AND SCIENTIFIC RESEARCH

AL-FURAT AL-AWSAT TECHNICAL UNIVERSITY

ENGINEERING TECHNICAL COLLEGE- NAJAF

A CONVECTIVE HEAT TRANSFER ENHANCEMENT UTILIZING BUOYANCY INDUCED FLOW IN A VERTICAL CHANNEL

A THESIS

SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING TECHNIQUES OF POWER IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR MASTER OF THERMAL TECHNOLOGIES DEGREE IN MECHANICAL ENGINEERING TECHNIQUES OF POWER (M.TECH.)

BY

WALAA ALI NAJE

B.Tch. Refrigeration and air conditioning engineering techniques

2017

Supervised by

Asst. Prof. Dr. ZAID M. Al-Dulaimi

October 2022

بسم الله الرحمن الرحيم

(يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ
بِمَا تَعْمَلُونَ خَبِيرٌ)

صدق الله العلي العظيم

(11) المجادلة

`

Declaration

I hereby state that the work in this thesis is entirely original to me and hasn't been used to apply for any other degrees or to submit to other organizations.

Signature:

Name : Walaa Ali Naje

Date: /   / 2022

`

Acknowledgements

First and foremost, praise be to God, His Majesty, for his countless blessings. Second: the populate Al-Bayt, peace be upon them, thanked the imams of guidance and dusk lamps .

I would like to express my deepest gratitude and appreciation to my supervisor, Professor **Asst**.**Prof. Dr. Zaid M. Al-Dulaimi** for his continued support of my studies during the research work.

I would like to express my thanks and gratitude to the head of the aviation department**, Asst.Prof. Dr. Mohamed A. Al-fahham** who supported me during the period of my master's study. My gratitude and sincere thanks to the Dean of Technical Engineering College – Najaf **Asst. Prof. Dr. Hassanain Ghani Hameed** and affiliates for their support and assistance during my preparation for this thesis. Special thanks to the Head of the Mechanics Department, **Prof. Dr. Dhafer Manea Hachim** , who gave me all the support and assistance under his authority during my work.

I would like to thank my family with sincere thanks and appreciation for being so kind and helpful throughout this study. Finally, I would like to thank all my friends and anyone else who has supported me in any way to finish my studies. I pray to God to continue to help them all.

Walaa Ali Naje

October 2022

`

SUPERVISOR CERTIFICATE

We certify that this thesis titled **"A CONVECTIVE HEAT TRANSFER ENHANCEMENT UTILIZING BUOYANCY INDUCED FLOW IN A VERTICAL CHANNEL"** submitted by Walaa Ali Naje , was prepared under our supervision at the power Mechanical Engineering Techniques Department , Engineering Technical College / Najaf , Al-Furat Al-Awsat Technical University , as a partial fulfillment of the requirements for degree of master in thermal mechanical engineering.

Signature :

Name : Asst.Prof.Dr. Zaid M. Al-Dulaimi

(Supervisor)

Data: 23 / 10 / 2022

In view of the available recommendation, we forward this thesis for debate, by the examining committee.

Signature :

Name: Asst.Prof.Dr .Adel A. Eidan

Head of Power Mechanics Tech. Eng. Dept.

Data: 23 / 10 / 2022

COMMITTEE REPORT

We certify that we have read this thesis titled " **A CONVECTIVE HEAT TRANSFER ENHANCEMENT UTILIZING BUOYANCY INDUCED FLOW IN A VERTICAL CHANNEL**" which is being submitted, by Walaa Ali Naje , and as Examining Committee, examined the student in is contents. In our opinion, the thesis is adequate for the degree, of Master of Technical in Thermal Engineering.

Signature: Mahmeed
Name: Dr. Mohammed Saad Abbas
(Member)
Data: 12/01/2022

Signature: Hamza
Name: Assist. Prof. Dr. Naseer Hameed Hamza
(Member)
Data: 12/01/2022

Signature: Dulaimi
Name: Zaid M. Al-Dulaimi
(Supervisor)
Data: 12/01/2022

Signature:
Name:
(Chairman)
Data: / /2022

Approval of the Engineering Technical College – Najaf.

Signature:

Name: Asst. Prof. Dr. Hassanain Ghani Hameed

Dean of Technical Engineering College – Najaf

Date: / / 2022

`

ABSTRACT

A experimental and numerical study was conducted for packaging material for room wall of room with use of several different gaps, locations of these gaps between the main wall of room and wall covering alucobond .The aim of this work is to reduce the heat load of room wall in current work. Which was built to be in direct contact with solar radiation, and second room contains thermal insulation in winter towards the south wall in (2022), January and February). The study showed effect of using thermal insulation on wall in reducing heat gain and loss through this wall. The experiment was carried out in winter at Technical University of Engineering (Najaf city, longitude 44 E and latitude 32.5 N), Iraq. Using test model of two similar sandwich panels. Two rooms (1.65m length , 1.5m wide and 1.5m high) facing south. First wall built of bricks (12cm) thick and covered with layer of cement (1cm) thick. As for second wall, is the as the first, but second wall of room is covered with alucobond material in front of built wall and contains air gaps that are between wall and the covering layer. Due to high absorbency of cement with low thermal conductivity of packing materials used, there was large discrepancy between internal and external temperature of non covered wall and insulated wall. This wall reduces the heat inside the room due to the low thermal conductivity of the insulating layer, and change effect is to reduce the amount of energy consumption for the purpose of cooling and heating in winter and summer. In this study, the outer wall was used to wrap the room with Alucobond coating material, and this insulating layer was made of different thicknesses and the most common one in the market was (4 mm) thick. This insulating layer is characterized by its good thermal insulation due to the low thermal conductivity of the used packaging materials. In the experimental study, air gaps (8,5 and 2.5 cm) were used, and the thicker they are, the more done use it will have. In this study, the possibility of obtaining a better gap is. The best air gap that reduces temperatures was chosen, 8 cm, because the alucobond layer of its specifications is made of a metallic material, whenever the air near the wall is hot, meaning that there is heat transfer.

`

Results of experimental work show that when using packaging materials with external air gaps energy will be saved, energy was saved respectively (92%, 88%, 73%), and from practical test it was found that best energy saving (8cm air gap 92%) because Heat travels from outside to inside and space acts as heating, heat in winter is always outside and not inside. Simulations were use ANSYS - FLUENT software. A recent study was conducted to evaluate optimum air gap thickness for room wall system with alucobond sheathing. The recent study was conducted using climatic conditions of a sunny day in winter in January 23/1/ 2022. According to presented results, it is clear that the thickness of the air gap (8 cm) on thermal distribution of room wall and movement of air is better than other studied gaps, and in this case heat distribution in the wall of room decreases. An increase in air gap increases the amount of air associated with gap, which reduces heat gained. The results showed that the thermal distribution of the wall of the test room for the first and second months had the highest value at 2 pm, as the temperatures at that hour reached 56 °C for the wall without alucobond , while the wall with alucobond reached 27 °C. The results were don’t use it for the experimental and numerical cases of the average temperature of the wall with and without alucobond and found that the numerical temperature rise is higher than the experimental case, despite the differences between the two cases, the acceptable results are about 10 %.

`

Contents

`

`

`

Nomenclature

Letter	Description	Units
A	Surface area	m^2
Q_{Al}	Heat Transfer alucobond wall	W/m^2
h_i	Convection heat transfer coefficient for membrane layer inner wall	W/m^2K
h_o	Convection heat transfer coefficient for membrane layer outer wall	W/m^2K
K	Thermal conductivity	W/mK
XΔ	Thickness of wall	m
T_R	Temperature Room.	°C
R_T	Total resistance	m^2K/W
Q_B	Heat Transfer brick wall	W/m^2
T_a	Ambient temperature out air	°C
T_r	Room air temperature	°C
Tm	Temperature mean	°C
T_{bi}	on the inner surface of a brick wall	°C
T_{bo}	Temperature on the outer surface of a brick wall	°C
T_A	Temperature alucobond	°C
hg	The convection heat transfer coefficient of air gap	W/m^2K
U	Overall Heat Transfer Coefficient	W/m^2K
Δx	Thickness of wall	m
Ri	Thermal resistance of the inner	m^2K/W
Ro	Thermal resistance of outer	m^2K/W

`

LIST OF FIGURES

`

`

`

LIST OF TABLES

`

CHAPTER ONE

INTRODUCTION

CHAPTER ONE

INTRODUCTION

1.1 General

Heat Transfer the heat will always be transferred from higher temperature to lower temperature independent of the mode. The energy transferred is measured in Joules (kcal or Btu). The rate of energy transfer, more commonly called heat transfer, is measured in Joules/second (kcal/hr or Btu/hr). Heat transfer plays a major role in the design of many other devices, such as car radiators, solar collectors, various components of power plants, and even spacecraft. Heat is transferred by three primary modes:

- Conduction (Energy transfer in a solid).
- Convection (Energy transfer in a fluid).
- Radiation (Does not need a material to travel through).

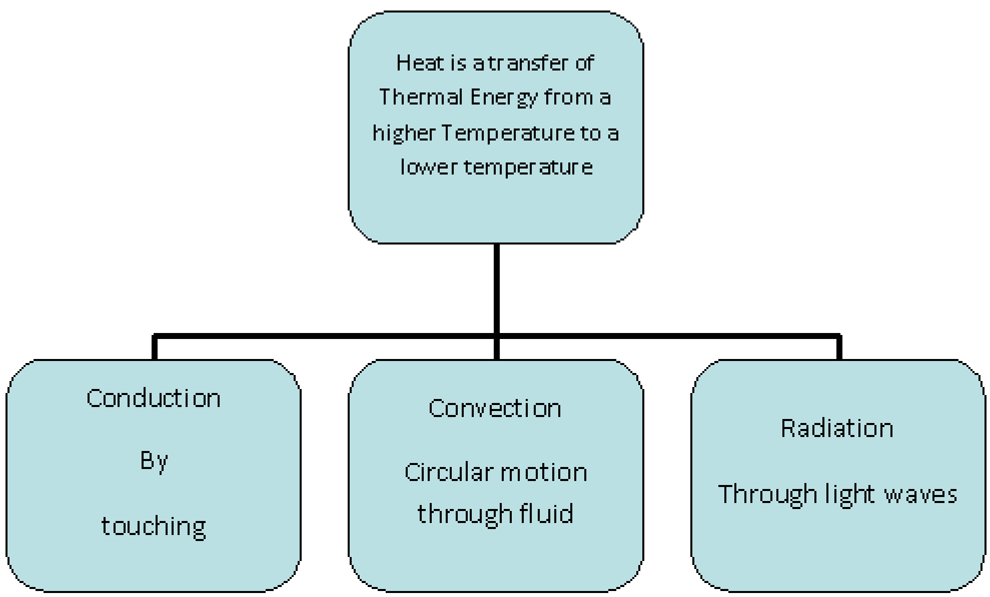


Figure 1. Types of heat transfer [29].

`

Energy saving is very important in practical engineering applications. The amount of heat lost is decreased when thermal insulation materials are used or an external wall packaging is used, and this effect reduces the amount of energy consumed for purpose of cooling and heating in the winter and summer. He explains the theoretical analysis of walls in buildings and the mathematical equations used to calculate heat gain and heat loss through insulated and non-insulated walls in this chapter. The primary heat source is the sun, and solar radiation is the primary factor affecting heat gain and loss. The effect of solar radiation relies on the location and orientation of the study room to the sun, and it changes throughout the year from day to day and hour to hour.

1.2 Solar Radiation

Solar radiation is radiant light and heat emitted by the sun, which is a huge source of energy. Solar radiation travels in the form of electromagnetic waves that travel across space uniformly in all directions to reach Earth and other plant. Solar radiation loses approximately half of its energy as a result of its reflection in the atmosphere and clouds When sunlight passes through the atmosphere, it is devalued as a part of it which is absorbed as it passes through [1].

1.3 Heat Transfer Through Composite Walls

It is a mechanism connected to walls equation for the outer surface balancing. Solar radiation is transformed into energy that passes through the walls. When the solar radiation falls on the wall, the heat is divided into three parts, a part that is reflected on the wall, a part that permeates the wall if it is a permeable wall, and the part that is absorbed. In this study there is transmittance and heat absorption, and the reflection is low because the wall of the user is lead-colored cement ,with a low reflection rate compared to a high solar absorption rate. Where we notice that the energy falling on the wall is absorbed and stored, and the heat storage process in the wall plays an important role in passing the amount of heat through it. Figure 2 show the heat exchange process through a wall.

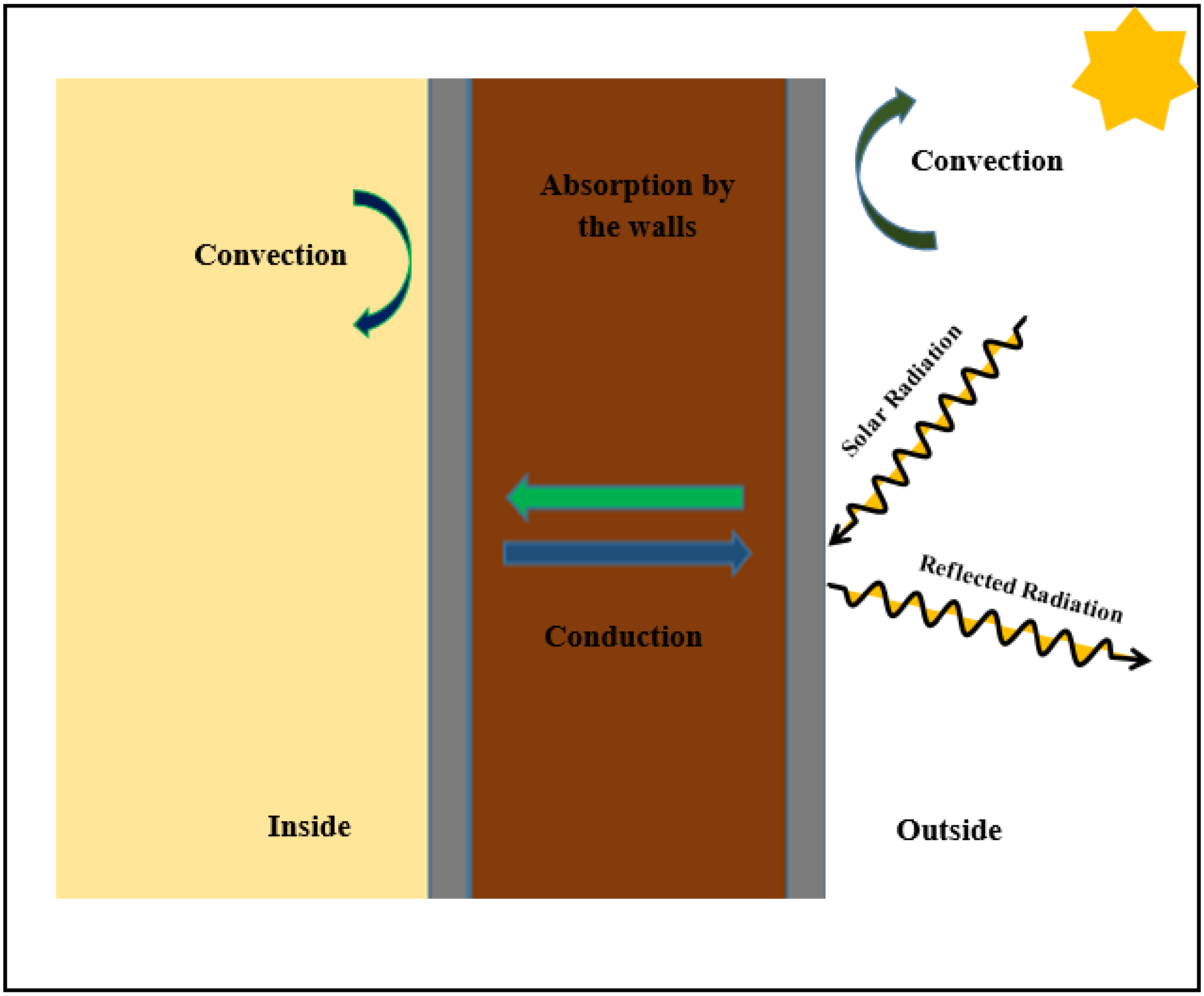


Figure 2. Heat transfer through composite walls.

1.3.1 Overall Heat Transfer Coefficient

Thickness and thermal conductivity of walls that heat is passed through have an impact on overall heat transfer coefficient. The easier it is transport heat from the solar radiation source to the heated rooms wall, higher heat transfer coefficient.

`

1.3.2 Thermal Conductivity [K]

Is a measurement of conductivity heat, conductivity thermal low conductivity materials conduct heat more slowly than high thermal conductivity materials. For instance, metals, which normally have high thermal conductivity, are more effective in transferring heat than insulating materials.

1.3.3 Temperature Outside Ambient Air [TA]

Seasonal weather is controlled by variations in ambient air temperature. The ambient air temperature outside has a significant impact on the energy balance of a building. The heat transfer via walls, exterior surfaces, and ventilation are all impacted by temperature of outside air. The temperature of ambient air influences natural ventilation. The amount of solar energy throughout the winter determines how much the outside air temperature rises and falls.

1.3.4 Temperature Mean [TM]

The heat transfer fluid's maximum mass temperature, which often occurs at the hot outflow of the fluid, is its highest average temperature. With each degree increase in mass fluid temperature between 20°C and 22°C, the thermal breakdown of the heat transfer fluid will double. The distribution of various temperatures between two sites where a fluid exists and the presence of temperatures between them are used to determine the bulk temperature.

1.3.5 Thermal Resistance [R]

Is the resistance a structural element exhibits to transmission of heat through its thickness; increasing this resistance increases the structural element's capacity to insulate heat. As result this value also known as thermal insulationis obtained by dividing the material's thickness by its conductivity.

1.3.6 Air Gap Thickness

According to property values, an air gap that is no thicker than 4 cm makes good insulator. Building insulation and temperature profiles in walls both require air gaps. When the faces of walls are doubled, we observe drop in values of surface transport coefficients of walls. Since double faces of walls are shielded from an air gap, there is significant drop in these coefficients.

1.4 Types of Exterior Insulations

Utilizing materials with capabilities to minimize heat transfer from the outside of the home to the inside in the summer and from the interior to the exterior in the winter is known as thermal insulation. It is parable . the heat that seeps through ceilings and walls, heat that seeps through doors and windows. Through ventilation holes, heat is transported. On hot summer days, it is believed that between 60 and 70 percent of the heat that air conditioning is supposed to remove permeates walls and ceilings [2].

1.4.1 Exterior wall

Technology for external wall thermal insulation is crucial for achieving external wall thermal insulation and cost savings show in figure 3 . In order to meet the energy-saving needs of residential buildings , the body of heat-insulated concrete blocks is mostly constructed of cement and sandstones that go through a special composite process. Housing has several technological and financial advantages over external wall thermal insulation systems and internal external wall thermal insulation systems [3]. The ideal room temperature is between 20 and 25 °C (ASHRAE) comfort conditions , with a humidity level between 50 and 60 percent. Additionally, you must take care of the wall insulation in this climate. Structures occasionally choose insulation, which must adhere to variety of specifications. The coefficient of thermal conductivity is the primary criterion for every heat-insulating material. Each contemporary style of outside wall insulation for homes has unique qualities. inadequate thermal conductivity. The capacity to control room climate [4].

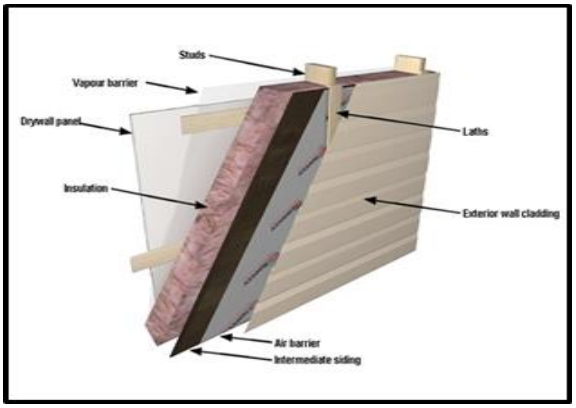
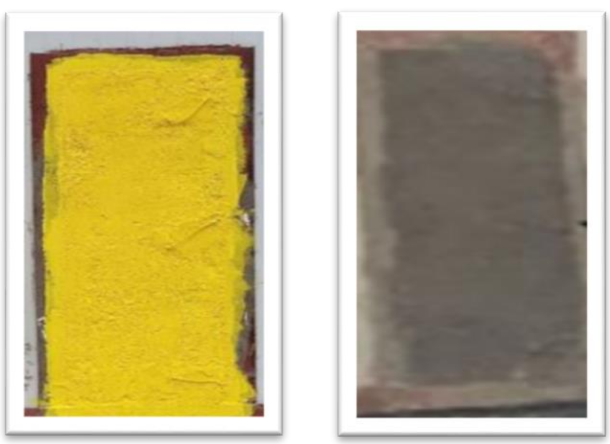


Figure 3. show exterior wall [3].

1.4.2 Exterior Wall Color

The study aims to explain how the different exterior colors of the building affect the heating and cooling loads in Iraq. Because of the state's intense heat and high ambient temperatures, exterior colors have a significant impact on the amount of light reflected or absorbed, which affects the amount of heat gained through the walls. The yellow color applied to the cement wall was chosen to study and compare the thermal behavior of the cold color with the imitation color [5].



Yellow **Black**

Figure 4. Exterior wall color [5].

1.4.3 Shadow Wall

The quantity of heat that is passed through the walls is decreased by shading them, which lowers surface temperature that is exposed to direct sunlight. The ability to lower the building's temperature and therefore lower the amount of energy needed for cooling represents solutions provided by nature to lower the temperature in hot locations. High temperatures, direct sun radiation, and other challenging climatic conditions affect hot and dry places, where facades serve as the main barrier against those conditions [6].

One of most crucial design tactics is shading techniques. It aims to block significant portion of the sun direct light. to lower temperature behind roofs, incident solar radiation, and surface temperatures outdoors. It also seeks to lessen the heat that solar radiation causes walls to absorb, requiring less energy for cooling. To obtain highest possible temperature reduction for areas exposed to direct sunshine, propose alternatives to shade walls made of brick and assess these alternatives using modeling software. As a result, less heat is transported through the walls [7].

1.5 Energy Consuming

Due to rising demand, high expenditures, and high expenses associated with this consumption, most nations in the globe are now paying attention to the rationalization of electrical energy usage. To rationalize electricity use, one must improve consumption in particular rather than reduce it. Due to a lack of an atmosphere that was conducive to these measures, the goals of rationalizing electric energy use were not met. In addition to financial and capital inputs for the production of power electrical energy can be saved in households through optimizing consumption. Electricity consumption rises as a result of the use of electrical equipment, which is also linked to an increase in emissions. Because of this, newly created electrical equipment must adhere to the stricter standards for energy efficiency and environmental protection [8].

The major goal is to rationalize electricity consumption and show how employing various types of lighting sources could result, in electricity use being reduced (selection of optimal source according to lighting, consumption and cost of electricity consumed). Temperatures inside and outside have an impact on electricity use. By measuring the consumption, the suitable hardware elements that can significantly affect the devices ultimate consumption are revealed. It can offer the best placement for the air conditioner's exterior unit that is far from solar radiation power range [9].

1.6 Problem Statement

The current work used the main wall of the room made of bricks and two layers of cement and exposed to direct sunlight, while the rest of the walls of the room were thermally insulated. The insulation material al was used, and this layer is not attached to the wall, and there is an air gap between , choosing the best air gap that provides maximum heating load. Its purpose is that the main wall of the room, when the insulation is removed for a certain time, becomes an air channel.The hot air ascending to the top will reduce the internal and external temperatures, and the heat transfer will be between the outside air and the wall of the room.

1.7 Objectives of The Study

1. Predict optimum Geometric of air gap the walls and choosing the best thickness that works to reduce the temperature of the room wall.

2. Experimental evaluate was conducted to the optimum air gap thickness for a room wall with alucobond packaging .

3. Compare experimental and numerical results are about 10 %.

`

CHAPTER TWO

LITERATURE REVIEW

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, previous research on the use of insulating materials for constructing external and interior walls as well as insulating packaging materials was review. Discuss importance of thermal insulation for external walls of buildings, how it lowers the heating and cooling load in winter and summer, and how solar energy affects daily temperature changes and heat transmission in internal and external walls.

2.2 Numerical Study

Ali et al. (2019)[10] studied Numerical to minimize the cooling load by using a new alternative in a space located in Baghdad, the study was prepared during the month of July and August of (2008), to apply The heat flux was reduced on the wall facing the South by (23.5%) and (33.7%) of the state of the air layer and glass wool with a metal plate on succession. Numerical study in was built a numerical model two-dimensional application of finite difference technique prepared within the (MATLAB) program has been built for this purpose. Finally, it was found that the numerical model was in a good agreement with the experimental data with a maximum discrepancy of (5 %) for the heat flux at the exposed walls.

Sanea and Zidan (2016) [11] Using numerical methods to examine impact of the position of the insulating layer on thermal performance of building outside walls. If temperature inside the house stays constant, is advised to place the insulating layer outside wall to provide best thermal performance. Under static circumstances, ideal position and thickness of insulation layer were examined, outcomes demonstrated that the placement of insulating layer had no impact on the annual heat transmission.

Fatima et al. (2015) [12] Pensated an examination of external walls effects numerical study directly on structure thermal efficiency. The study findings demonstrated that the brick walls external cladding material The hole with thickness of 130 mm, best thermal and coating material, attained maximum economic rate in amount of electrical energy, exterior, low mass cladding materials like Alucobond and black alabaster have worst thermal performance because they obtain a lower percentage of electrical energy economy. Thermostone has achieved an affordable percentage as wall-building material. Operation was done, and the electrical energy is greater than the percentage obtained from perforated brick material, with a thickness of 240 mm. When the building material for perforated brick walls is 240 mm thick, increasing the air gaps thickness from 25 mm to 100mm reduces the amount of electrical energy consumed by 6.6% , and by 4.3percent when it is construction material for thermostone walls.

lbrahim et al. (2016) [13] Study enhanced placement and depth of insulating layers in building of exterior climatic walls in the coastal Mediterranean region, as well as through numerical simulation. Their findings demonstrated that the inclusion of the insulation layer decreased the heating and cooling system by 25 percent for continuous operation. Installing insulating layer on the inner side of walls reduced energy demand during intermittent operation by 15% as opposed to doing so on outer wall side. Ideal thickness varies from 3-5 cm depending on season and climate.

2.3 Experimental Study

Nazar et al. (2017)[14] Studied the use of reduced the cooling load and improved insulation effect on Iraqi buildings using the geothermal energy storage phenomenon. A numerical study was conducted for the Iraqi architectures (Baghdad) on 21st July to reduce the cooling load by using a new system of energy resulting from geothermal energy. For this purpose was extended vertical plate high thermal conductivity to a depth (3m) as part of the structural composition of the eastern and southern two walls.

The study shows that when using only the plate (without insulation) reduce the cooling load rates (13.2%) and (12.7%) of the eastern and southern two walls in a row. The study also shows that when the use of thermal insulation (Thermal conductivity 0.04 W/m.K) in different arrangements (positions) of the wall, plate succeeded to reduce the cooling load of the southern wall rates (8%, 14.5% and 40%) and (8%, 15.8% and 41.3%) at the eastern wall.

Sajad et al.(2016) [15] studied of using thermal insulation material for new building walls in Iraq to reduce heating and cooling load. The experimental study includes built two room dimensions of each (1m length,1m width,1 m height) in Al kut city located at (32.5 latitude). The model is set to be each wall faced ,west , east ,south and north direction. The models or room built from thermo-stone (20cm) , brick(24cm) and sandwich panel (5cm). Another type of thermal insulation is(styropor) used to test and compared with brick wall. The heat gain was calculated from all the above insulations material compared with normal brick room. The results of study showed that the sandwich panel saving energy about 70% is the best model, while the styropor saving energy about 54.28%.and the thermo-stone saving energy about 33%.

David et al. (2018) [16] investigated the impact of locally available thermally insulated wall materials on Burkina Faso air conditioning demands. The walls are constructed of thermal insulation materials and a composite material comprised of brick and cement (white wood, red wood, and two combined insulation boards). The study findings show that compared to other homes, the cement and brick combination saves roughly 8.4 percent of energy. Regarding the ceiling, the study findings showed that utilizing 1.5 cm thick red wood would result in a 6.2 percent energy savings, while using cement and w insulation boards ould result in a 11.1% energy savings.

Yuan et al. (2017) [17] The aid of both internal and exterior insulation, two external wall types were built. effects of thermal insulation on energy use when air conditioning systems operate intermittently. Main elements impacting transmission loads from intermittently operating systems were determined by results to be heat dissipation and storage of inner layer during nonoperation, When air conditioners for external and internal insulation walls were turned on and off, inside surface and air temperatures had a high average temperature. The room with internal insulation saved 19 percent more energy than room with exterior insulation, and it had more significant effect on energy.

Maytham et al. (2016) [18] In Iraq, researchers have researched several types of insulating walls for ambient temperature of solar energy source in summer to limit heat transfer to room area. In this study, local natural insulation made of palm fibers, reed mats, local plastic was used to insulate air conditioners to save energy. According to study findings, employing reeds as insulation can reduce energy consumption by 55.5 % when compared to other natural materials (plastic and palm fibres.

Azarnejad et al. (2017) [19] The relationship between temperature of the relevant surfaces and optical reflection of building facade has been revealed as part of an investigation into impact of building facade optical reflection on thermal behavior in Vienna. Building with yellow exterior wall facades were selected in variety of methods. As cooling load drops by around 40percent when compared to buildings with polystyrene insulation, findings showed that optical reflection of yellow building facades has substantial impact on interior temperature of the building.

`

Atiff (2016) [20], studied the effect of reduction heat transferred from or to inside space of building by covering external walls by packing materials. The researcher built a model (2×1×1) m, located in Baghdad city (L = 33.2 N°), on the 3rd floor of the building and (2 x 1) m^2 east wall used to purposes of the work, while the researcher isolating the other surfaces and walls from inside by styropor insulation about 200mm thickness and used 0.5 tons to air conditioner to purposes provide standard cooling conditions. The result of study indicate that, the metal sheet painted with(10 mm) insulation and thermal plastic paint used as a cover for ordinary wall saved (57%) from power consumption. while when using this material without thermal insulation saved (46.2%) while solid flooring brick with insulation saved (39.5%)from energy , while when using hollow plastic board (for decorative) saved (42.5%) from energy and when using colour metal sheets with air gap saved (36.4%),while using hollow faced brick with thermal insulation saved (40.22%) of electrical energy consumption to purpose of Air-Conditioner, the ceramic with insulation saved about 31.9%. While all the material , fiberglass, hallan stone, like marble, porcelain, with (10 mm) insulation "reduction the electrical energy less than 30%.

Hayder M. B (2012) [21] experiment study for wall thermal performance with insulation (alucobond) in winter season. The dimensions of insulation is (1 m^2) and a (3 mm) of thickness. He used Air gap between the Q-Bond and wall (5 mm). The external and internal temperatures on side of the wall were read with the Q-Bond and without (alucobond)for 10 hours on 2, 5, and 16 December for different climatic in 2010 .The result of study indicate the better point to readings was found in the middle of the face wall. And the amplitude measured of the inside wall with Q-bond was less from measured amplitude to the same wall without the insulation Q-bond.

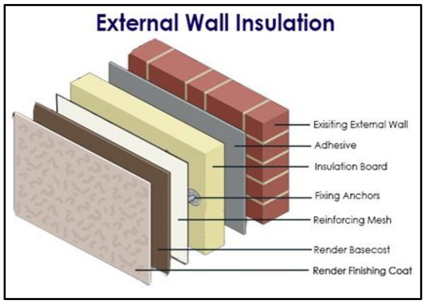
Ali et al. (2017) [22] studied comparison between the modern packaging material and traditional packaging for walls of buildings in Iraq. The results of study showed when using the external packaging materials that the percentage reduction in cooling load did not exceed 2%.while when using the internal packaging material that the percentage reduction in cooling load about between (12% -10%).

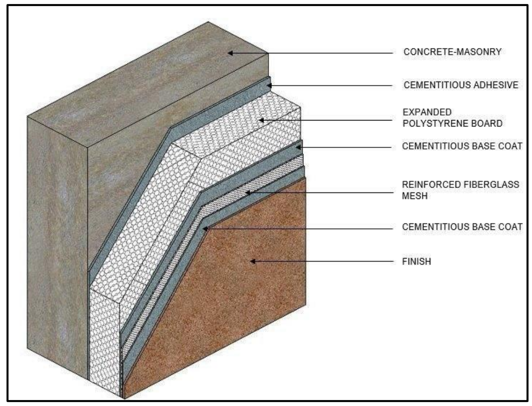
Nadia et al. (2010) [23] studied concrete pieces wall coverings from inside and false ceilings with dimension 200x200x300mm, using Iraqi plastic factory wastes by mixing with cement, sand, water, using Polyvinyl Chloride and Acetate (PVC) to give a high resistance to corrosion, moisture and friction. Two mixes were used, first mixture (A) is 1 cement: 1 sand: 2 plastic wastes by size, the second mixture (B) is 1 cement: 2 sand : 3 plastic wastes by size.

The thermal insulation of mix (A) is 0.322 W/m^2 C and for mix (B) is 0.375 W/m^2 C. That's a good comparer to cut packaging used. This piece good pressure of capability, feature being its survivability and resistant to cracking and abrasion and moisture as it thermal insulates good.

`

Table (2.1): The Summary studies

Author	Type of Study	Insulation of study	Figure of author	Result summary
Fatima et al. (2015)	Numerical	Thermostone		Energy consumed by 6.6% , and by 4.3percent when it is construction material for thermostone walls.
lbrahim et al. (2016)	Numerical	Exterior wall		Installing insulating layer on the inner side of walls reduced energy demand during intermittent operation by 15% as opposed to doing so on outer wall side.

Sajad et al.(2016)	Experimental	Styropor insulation		The styropor saving energy about 54.28%.and the thermo-stone saving energy about 33%.
Hayder M. B (2017)	Experimental	Alucobond		The result of study indicate the better point to readings was found in the middle of the face wall.
David et al. (2018)	Experimental	Insulation boards		Result in a 11.1% energy savings.

2.4 Summery

According to previous research, the majority of researchers have used thermal insulation materials, packaging materials and other methods to reduce the heating and cooling load. Additional studies were also conducted on the use of insulation in walls to enhance thermal performance. According to the type of thermal insulation used in the walls and the packaging materials used during the construction of new and old buildings, previous research has provided different figures for the energy saving percentage. When constructing buildings, it is necessary to study this subject because it helps to reduce the amount of electricity needed for heating and cooling in winter and summer. In order to understand the importance of using insulation to reduce electrical energy consumption in buildings in Iraq and around the world, an alucobond exterior wall insulation material with an air gap between the room wall and packaging wall used for this study.

`

CHAPTER THREE

NUMERICAL STUDY

CHAPTER THREE

NUMERICAL STUDY

3.1 Introduction

The main objective of this study is to use several air gaps between the main wall of the room and the covering layer used (alucobond), to take advantage of them to provide a space in which the air moves and is used for heating and cooling. The study was in the winter season, during January and February, and the test wall was facing south, using ANSYS- FLUENT program .The pattern air flow and temperature distribution could be studied using the path lines and the contour result obtained from the simulation. The simulation was carried out according to the specifications prepared for the current study. It explains the difference and analysis in the results obtained from the simulation for several air gaps, and these gaps act as thermal insulators. Using program ANSYS-Fluent Theoretical results for calculating temperature distribution on the external and internal walls and the heating load with energy of heat flux in winter.

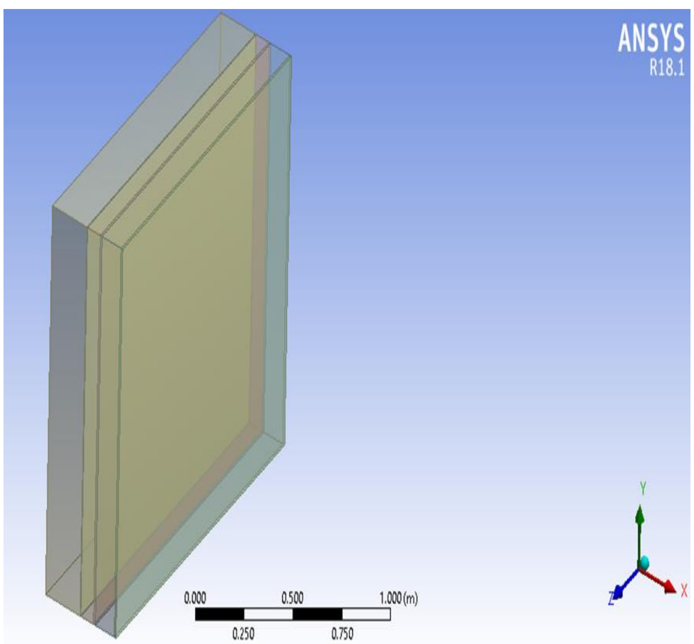
3.2 Numerical Analysis Room / Wall

To study and solve complex fluid flow and heat transfer problems in a chamber wall, computational fluid dynamics (CFD) technology is used. CFD is a computer-based program to simulate the behavior of the wall, and the Ansys program was used as a CFD simulation program, and it works by solving multiple algorithms and equations for the fluid flow of interest in the study area, which included the initial and boundary conditions on the study required for the area. CFD theories give solution reliability, as they can solve several system configurations at the same time and at a lower cost compared to other empirical studies. In the current study, a CFD simulation technique was used to investigate the effect of Using the air gap between the walls and choosing the best thickness that works to reduce the temperature of the room wall.

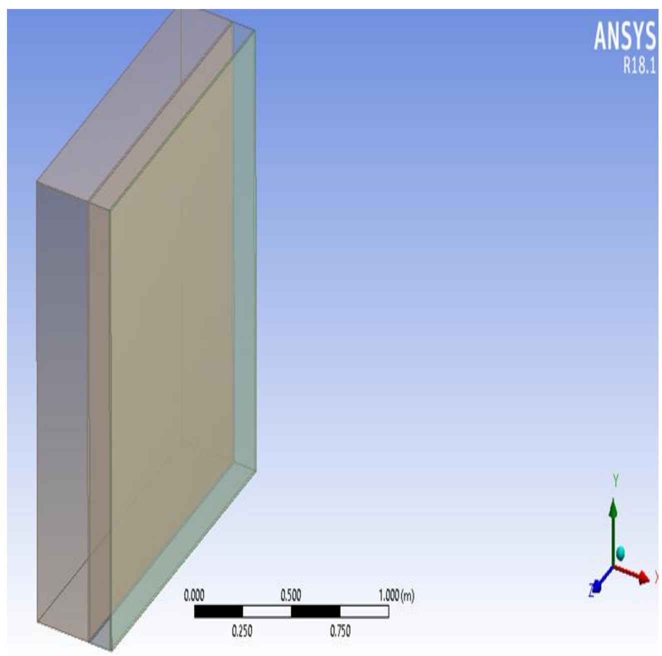
3.2.1 Process of CFD

1. Geometry Model

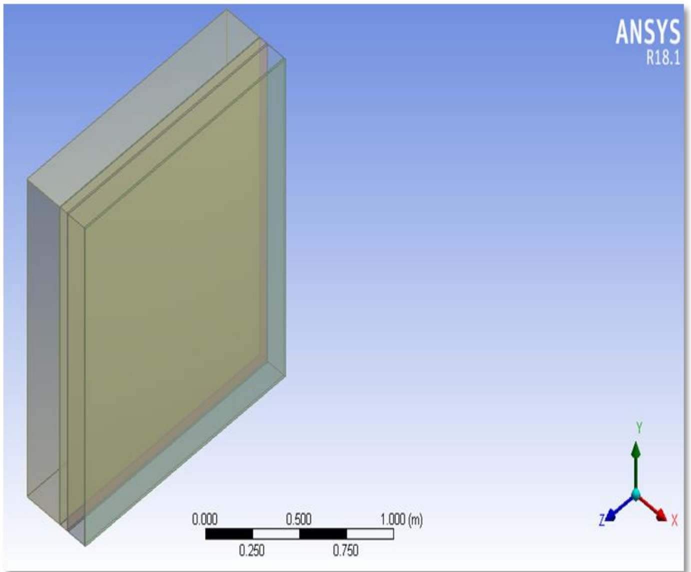
The first stage of building the proposed case structure is in the design process, which also includes creating the model that will be tested. Two chambers of equal dimensions and external conditions in terms of temperature and wind speed were drawn as part of the project, but one was installed in front of a layer of Alucobond, with different air gaps between a sheathing wall and the main chamber wall. The main wall of the rooms is exposed to direct sunlight, while the rest of the walls are thermally insulated. Also ceilings made of panels .Insulated, and the geometry of the insulated and non-insulated chamber is shown in Figures 3.1.

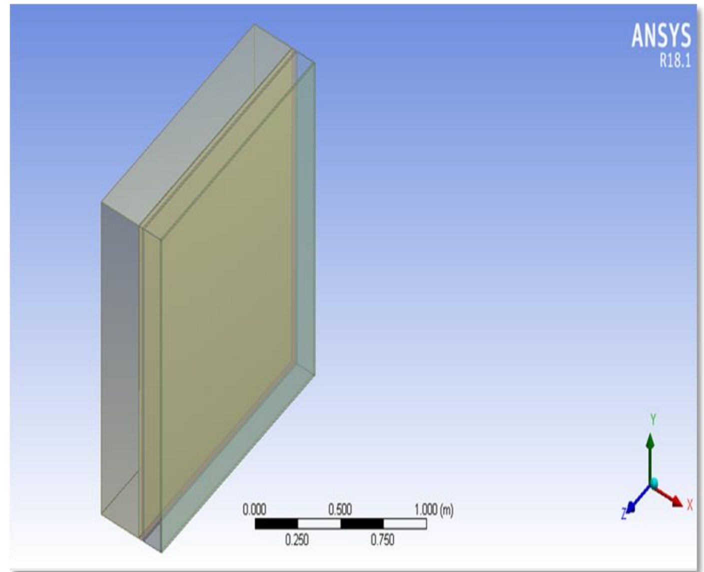


With air gap (8 cm)



Without air gap



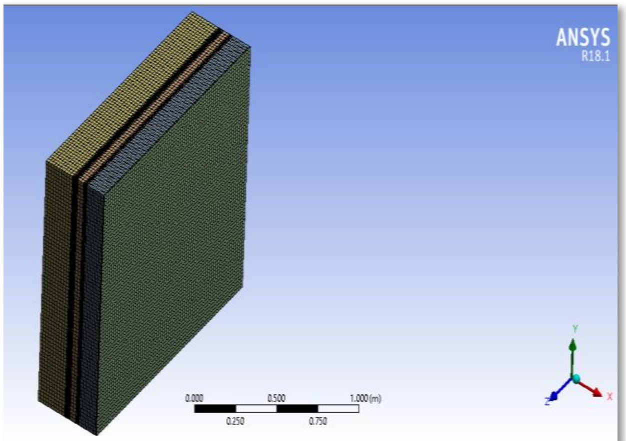


With air gap (5 cm) With air gap (2.5 cm)

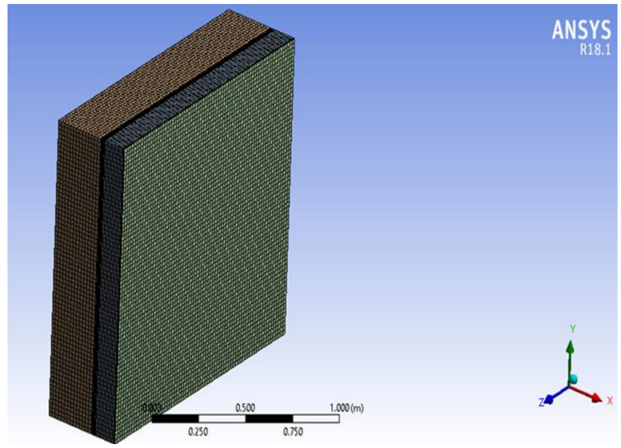
Figure 3.1 show geometry model room without air gap and with air gap.

2. Meshing Model

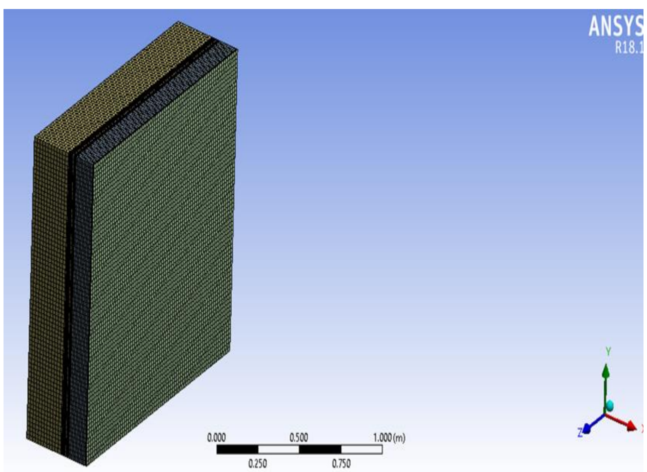
Step by step, geometry is broken down into micro-components. Cross-linking is an important step made to prepare for the solution steps. The grid must be suitable for the condition used (fluid flow, heat transfer), therefore, the main criteria must be specified, that is, type and form component used, as well as the control network. bit Surface cube element shape as a result of using a 3D model. The type and shape of the hexagonal mesh with a netting quality of 0.9. The experimental and theoretical 3D model was done in winter, and the wall to be tested was facing south. Shows network work for an isolated room The uninsulated dimensions are (1.5 m x 1.65 m x 1.5 m). The room wall is built of bricks and two layers of cement in front of them an insulating layer of alucobond (4 mm), with an air gap between the main wall of the room and a wrapping layer, and these gaps act as a good insulator. The model is made on the (XY) axis, while the heat flow is applied to the built room wall towards the (X) axis are shown figure 3.2 and tables 3.1 and 3.2.



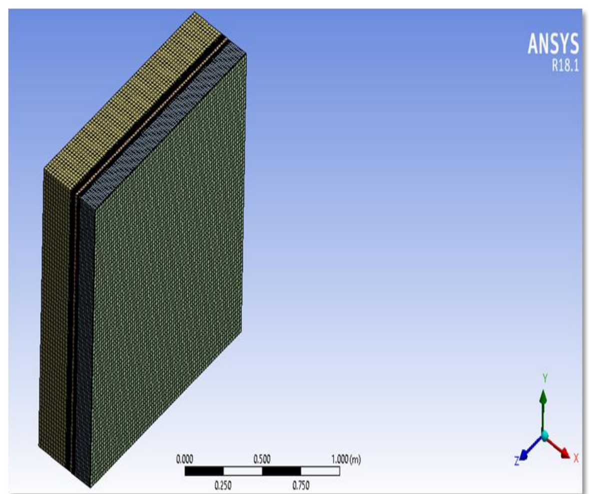
Without air gap (8 cm)



Without air gap



Without air gap (2.5cm)



Without air gap (5cm)

Figure 3.2 show meshing model room without air gap and with air gap.

Table 3.1show Meshing Information for room without air gaps.

No.	Domain	Nodes	Elements
1	Air	99280	91656
2	Cement	14892	48240
3	Brick	54604	9648
4	Cement	14892	9648

Table 3.2 show Meshing Information for room with air gaps .

No.	Domain	Nodes	Elements
1	Air	143956	130248
2	Alucobond	14892	9648
3	Cement	14892	9648
4	Brick	54604	48240
5	Cement	14892	9648

3.2.2 Governing Equations

Numerous heat transfer activities take place in test chambers because they tend to balance heat inside the chamber because walls are exposed to outside weather conditions (transient). Heat is produced when solar radiation strikes a wall, and this heat can be retained inside a wall through thermal conduction. The heat is then circulated naturally through the room. On other hand, heat is lost from the insulated and uninsulated rooms inner and outside walls. The equations for heat transmission and fluid movement must be taken into consideration in order to assess thermal performance of the room under state analysis. The governed assumptions is by equations of Navier-Stokes .

`

1. Continuity equation

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$ **(3.1)**

2. Momentum equation

- **X. direction**

$$\frac{\partial u}{\partial t}+\frac{\rho u\ \partial u}{\partial x}+\frac{\rho v\ \partial u}{\partial y}+\frac{\rho w\ \partial u}{\partial z}=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)$$

(3. 2)

- **Y. direction**

$$\frac{\partial v}{\partial t}+\frac{\rho u\,\partial v}{\partial x}+\frac{\rho v\,\partial v}{\partial y}+\frac{\rho w\,\partial v}{\partial z}=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)-\rho\beta g(\mathrm{Tin}+\mathrm{Tout})$$

(3. 3)

- **Z. direction**

$$\frac{\partial w}{\partial t}+\frac{\rho u\,\partial w}{\partial x}+\frac{\rho v\,\partial w}{\partial y}+\frac{\rho w\,\partial w}{\partial z}=-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)$$

(3. 4)

Where:

Bouyancy Force =ρβg(Tin+Tout) **(3. 5)**

$\beta = \frac{1}{TM}$ **(3. 6)**

$T_M = \frac{\mathrm{Tin}+\mathrm{Tout}}{2}$ **(3. 7)**

3. Energy equation

$$\frac{\partial T}{\partial t}+\frac{u\,\partial T}{\partial x}+\frac{v\,\partial T}{\partial y}+\frac{\rho\,\partial T}{\partial z}=\frac{K}{\rho Cp}\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right) \quad (3.8)$$

3.3 Heat Transfer Analysis

Unsteady state heat transfer in room walls The heat flow through a wall depends on the temperature difference on its surfaces, on thermal conductivity of the materials used, and their thickness. The temperature difference is a factor that depends on the environmental .unsteady-state heat transfer through a building multilayer wall and the thermal resistance network. factors, but the thickness and the conductivity are material characteristics. A bigger material thick means a lower heat flow, and therefore, a lower conductivity. The thermal resistance is proportional to the thickness of the wall and inversely proportional to its thermal conductivity. Thus, a building wall with a high thermal resistance is a good insulator, and one with low thermal resistance is a weak insulator.

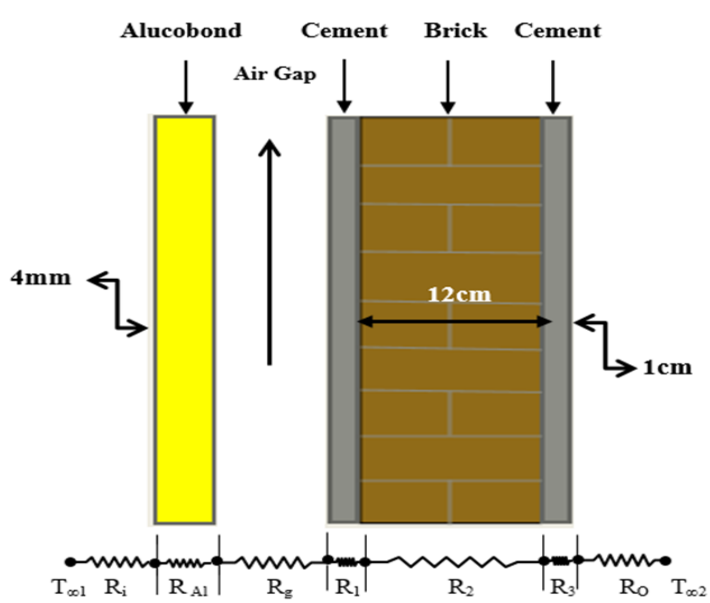


Figure 3.3 transient heat flow through wall with multilayer walls (alucobond) and a thermal resistance network.

`

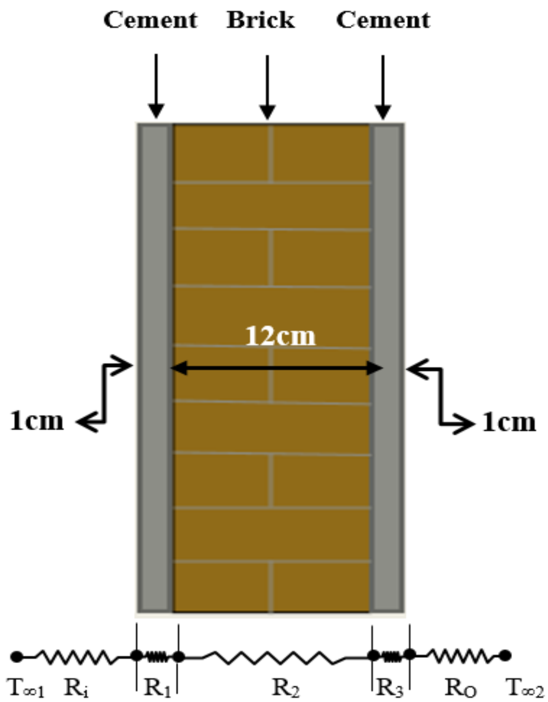


Figure 3.4 Transient heat transfer through multilayer wall room without (alucobond) and the thermal resistance network.

3.3.1 Equations used in the experimental study

- Thermal Resistance

$R\ total = R_{conv.in} + R_{cond.\ wall} + R_{conv.\ out}$ **(3.9)**

- Heat Transfer Rate Convection and Conduction walls

$Q\ wall = UA(T_M - T_R)$ **(3.10)**

- Overall Heat Transfer Coefficient

$U = \frac{1}{RT}$ **(3.11)**

- Save Energy

$S.E = \frac{(QW - QA)}{QW}$ **(3.12)**

- Temperature Mean

$$T_M = \frac{(Tin + Tout)}{2} \quad \textbf{(3.13)}$$

3.4 Grid Independence Test

In order to reach the appropriate size of the appropriate face network Work, the retinal faces independence test was performed on the model To see the accuracy of the results, the test provides an option for A suitable network gives a solution to the differential equations. Figure (3.5) Displays the number of nodes for network faces 117645, 156744, 212223, 297644, and354673 Finds the outside wall temperature of a room from a heating process For the room wall, from the figure below, the best grid has been reached the number is 117,645 users. In fact, a better resolution of the grid size can be obtained with more nodes in results, but more networks will make longer arithmetic time.

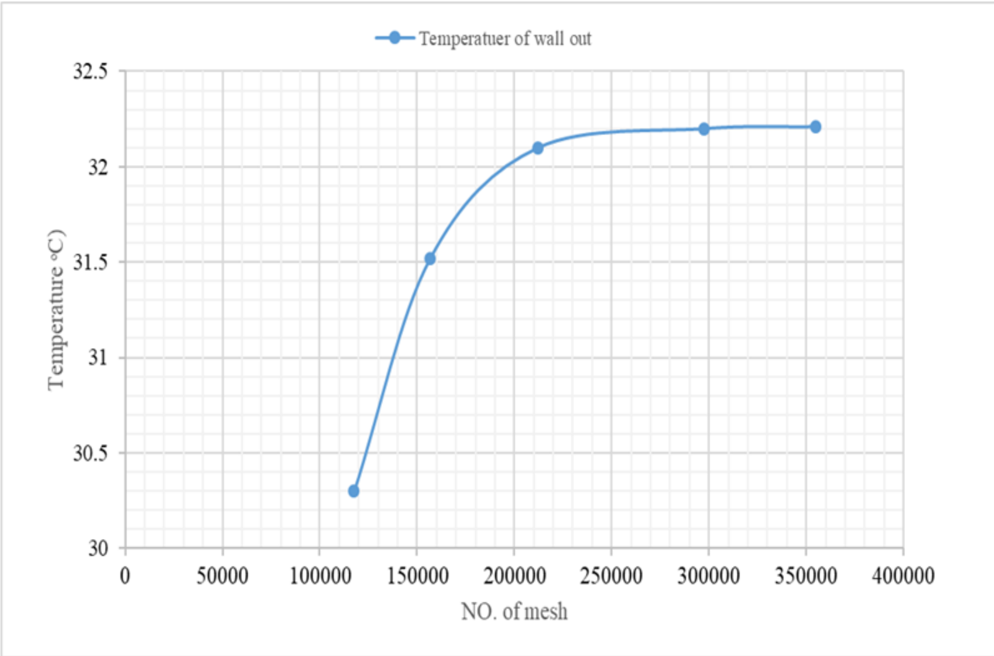


Figure 3.5 Relationship show Temperature of wall out and Mesh value .

3.4.1 Physical Model and Assumption

The heat flux is displayed on the wall of the main building of the room. the remains walls room thermally insulated, The speed inside the walls is zero. As for the conditions inside the room, with room temperature constant 25 °C with convective heat transfer coefficient of 9.37 $W/m^2.k$ [24]. While outside the room is controlled by external atmospheric pressure with external environment temperature, Table 3.3 . following assumptions in the numerical analysis:

- The system operates in unsteady state conditions and the simulation is (3-D).
- Laminar flow.
- Heat transfer with the fluid flow.
- The air flowing is incompressible.
- The heat flux constant.
- Homogeneous material.
- Convection heat transfer coefficient for inner wall equal (9.37 W/m2.k) at air static [24].
- Convection heat transfer coefficient for outer wall equal (34.1 $W/m^2.k$) at speed wind 24km/h with winter [24].
- Nu and Re at wall flow laminar equal $Re \leq 5 * 10^5$ and Nu = $\frac{h.L}{K} = 3.66$ [25].

`

Table 3.3 Physics Domain

Domain Air Gap	
Type	Fluid
Material	Air at 25 °C
thermal conductivity	0.026 w/m k
Density	1.29 Kg/m^3
Heat Specific	1.005 k J/kg k
Type flow	Laminar
Analysis state	Transient
Domain Alucobond	
Type	Solid
Material	Aluminum
Thermal conductivity	0.15 W/m k
Domain motion	Stationary
Analysis state	Transient

Domain Air Room	
Type	Fluid
Analysis state	Transient
Material	Air at 25 °C
Type flow	Laminar
Domain	Stationary
Convection heat transfer coefficient	h=9.37 W/m^2.k
Domain Wall Room	
Type	Solid
Analysis state	Transient
Material	Brick common and cement
Domain motion	Stationary

3.4.2 Boundary Conditions

The room wall main of the were provided with a heat flux flow and the flow velocity in wall equal zero and velocity air gap 0.01 m/s [26] . The rest of the walls are thermal insulated adiabatic condition was Q=0.

Table 3.4 Boundary Conductions

`Boundary –Air Gap (inlet)	
Type	Velocity inlet
Heat transfer	Static temperature
Static temperature	25 °C
Inlet velocity	0.01 m/s
Boundary – Air Gap (outlet)	
Type	Pressure out
Mass and Momentum	Average static pressure
Relative Pressure	0 Pa

Boundary – Wall Alucobond	
Type	Wall
Heat transfer	Temperature fixed
Temperature fixed	At 30 °C
Mass and momentum	No slip wal
Boundary – Wall Room Main	
Type	Wall
Heat transfer	Heat flux
Heat flux	1000 W/m^2

`

CHAPTER FOUR

EXPERIMENTAL STUDY

CHAPTER FOUR

EXPERIMENTAL STUDY

4.1 Introduction

The experimental work chapter includes using package material placed in front of building walls to reduce heating load, increase internal temperature in winter, and reduce cooling load and internal temperature in summer. Saving energy for buildings by using wall shading and thermal insulation makes building maintain appropriate temperature for time without need operate air condition for length periods, on other hand, insulation thermal reduce leakage heat transfer from (outside to inside), Current was work carried out Technical College Engineering for (Al-Najaf city, longitude 44 E and latiude 32 N) model of first room, which was built to in direct contact with solar radiation, and second room contains heat insulation in winter in wall direction of south in (2022). January and February).

Study showed effect of using thermal insulation on wall to reduce heat gain and loss through this wall. The experimental work consists of two walls of same distance and direction, one of them consists of bricks and two layers of cement and the other wall is same as the first, but the thermal insulation (alucobond) is fixed on it. This wall reduces heat inside room due to low thermal conductivity of insulating layer and benefit of this effect is to reduce amount of energy consumption for purpose of cooling and heating in winter and summer**.**

4.2 Room Models

The test model was created as depicted in Figure 4.1, it primarily consists of two identical cubic chambers that share the same external characteristics. One of two rooms has no insulation, while the other is situated in front of an insulating layer made of 4 mm thick alucobond material that measures 1.65 meters in length, 1.65 meters in width, and 1.5 meters in height. Two rooms used as study model have ceilings made of sandwich panels with thickness of 5cm, thermal conductivity (0.034) W/m.K, with the exception of the wall facing sun. This prevents heat from leaking in from outside to inside and vice versa.

`

Room size (width 1.5 m, length 1.65 m, height 1.5 m). First wall is made of brick and packaging with cement; this wall is exposed to direct sunlight. Second wall is constructed similarly to the first, but it also has an insulation layer and is sealed on both sides with cork. In order to reduce thermal transfer from the ground to the inside of the rooms, the floor of the rooms is lifted from the ground by 0.3 m. Each room's floor is built of sandwich panels with a 1.4 m thickness.

Figure. 4.1. Show Rooms Model .

4.2.1 Types of Walls Room

1. Wall built of bricks and cement without package Alucobond

The wall of room was built first of ordinary bricks with two layers of cement with thickness of 1cm. Thermal conductivity of cement (0.32 W / m. K) [27] used in installation of bricks as shown in Figure 4.2 . Dimensions of brick wall (H)1.5m, (W) 1.5m & thickness 12cm thermal conductivity of brick (0.54 W /m. K) [27] and dimensions of brick length 23cm width 12cm height 7cm.

2. Wall built of bricks and cement with package Alucobond

Similar to the first rooms wall, the second rooms wall was constructed using regular bricks and two layers of cement that were each one centimeter thick. Thermal conductivity of cement (0.32 W / m K) was used to install bricks, and Figure 4.2 shows the brick walls height, width and thickness in addition to the thermal conductivity of the brick (0.54 W / m K) and its length, width, and height measurements. However, a heat-insulating layer made of alucobond that has thermal conductivity (0.15 W/m. K), dimensions of 1.5 m x 1.65 m x 4 mm is applied. Insulator lowers the walls internal and external temperatures by causing hot air to climb to the top.

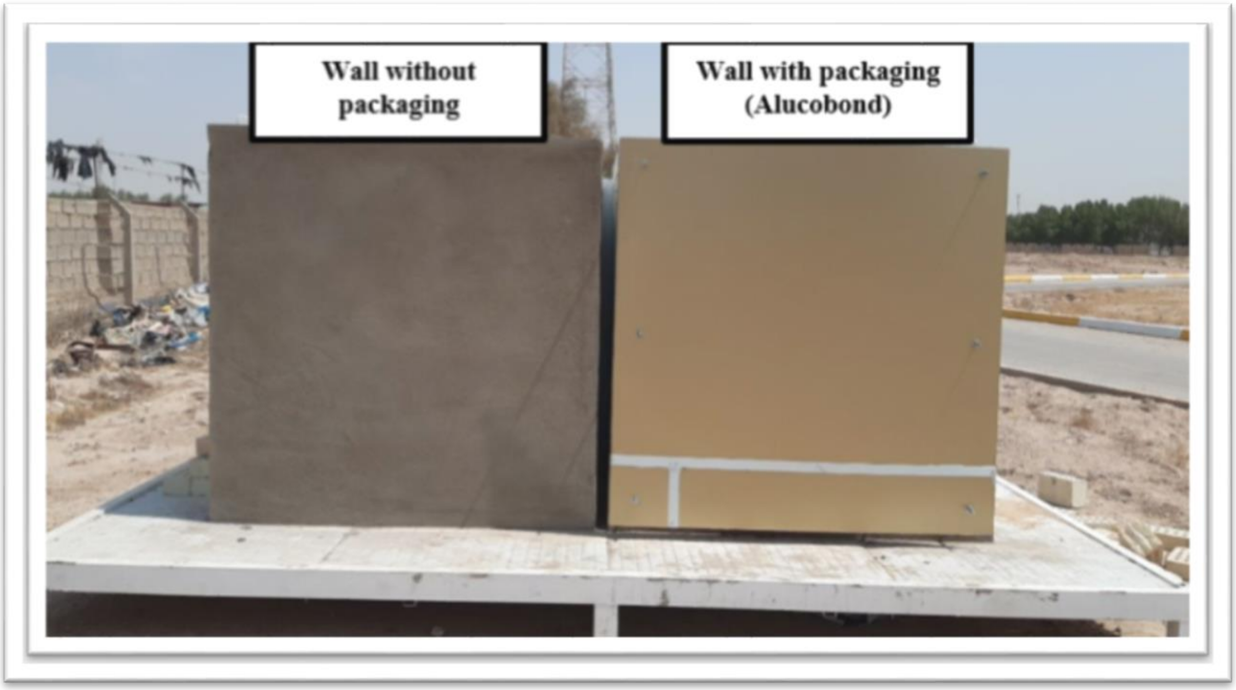


Figure .4.2. Wall brick and layers cement with and wall packaging (Alucobond).

4.3 The Types of Test

Experimental work is to package the outer wall of room with Alucobond layer with the presence of air gaps between the main building wall and wall of the insulating layer. Work begins in at 10 am and continues until 5 pm , and work is 8 hours a day during January and February. Experimental work was done during the winter season .

4.3.1 The Package (Shadow) Material External

4.3.1.1 Alucobond

A wall of alucobond was added to brick and cement wall measuring (1.65 m x 1.5 m) and thickness (4 mm). The insulating layer is not attached to wall and is separated by air gaps(8,5,2.5 cm) between the brick wall and alucobond wall . Test period for January and February 2022 from 10 am to 5 pm, comparing results with the brick wall and cement without package Figure 4.3 .

Figure . 4.3. Wall with external package (Alucobond).

4.3.1.2 Properties of Alucobond

1) Alucobond is composite plate consisting of two aluminum sheet and plastic core. (aluminum composite panel) of different thickness, where is the basis for its thickness.

2) These alucobond panels are made by with different thicknesses including 4mm, the most popular in domestic market is 4mm.

3) It is characterized by its light weight ability to form and resistance to external climatic conditions.

4) Alucobond is characterized by its good thermal insulation.

4.3.2 Insulation Placed Between The Two Walls The Main wall and Wall Layer Package

1. Air Gap

The wall is made of bricks and two layers of cement with thickness of (14 cm) with an insulating layer of a wall packaging (alucobond) between them are air gaps (8,5 and 2.5 cm). Winter probation period for each gap is Jan (23-25 - 2022 at 10 am-5 pm) show Figure 4.4 . And from February (6 to 8 from 10 a.m. to 5 pm). and from February (27-28 from 10 am. to 5 pm) , Compared with wall without packaging. during the day heading south. The idea of placing air gap between main wall of room and packing material is to provide a space in which air that is used for heating and cooling moves show Figures 4.4 and 4.5 .

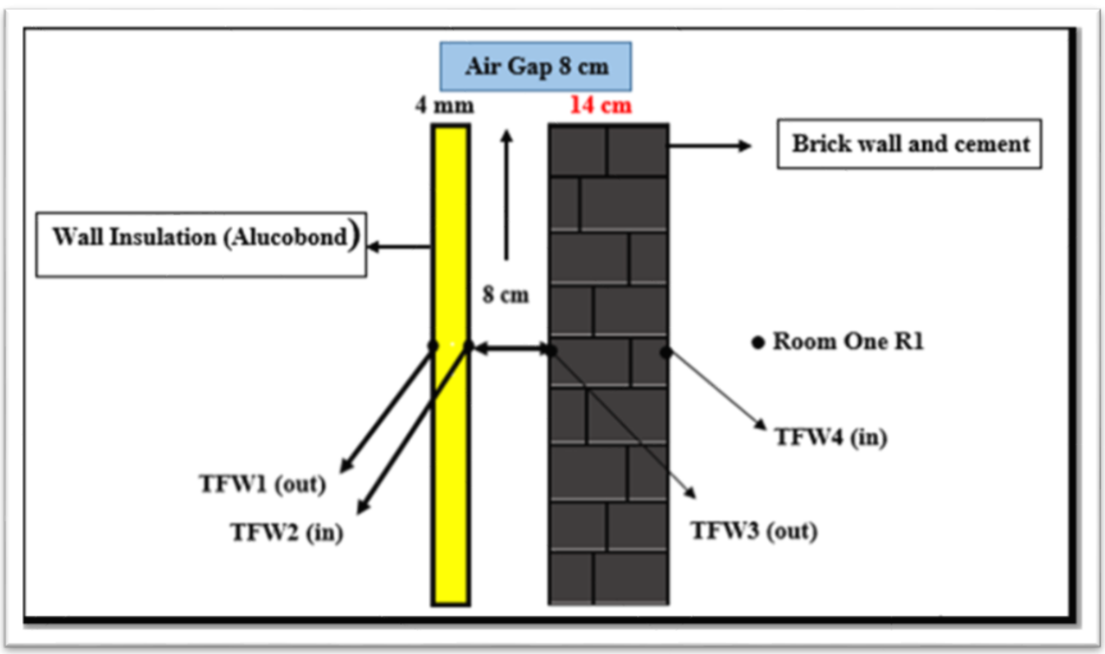


Figure .4.4. Wall brick and two layer of cement with air gaps (8,5&2.5 cm).

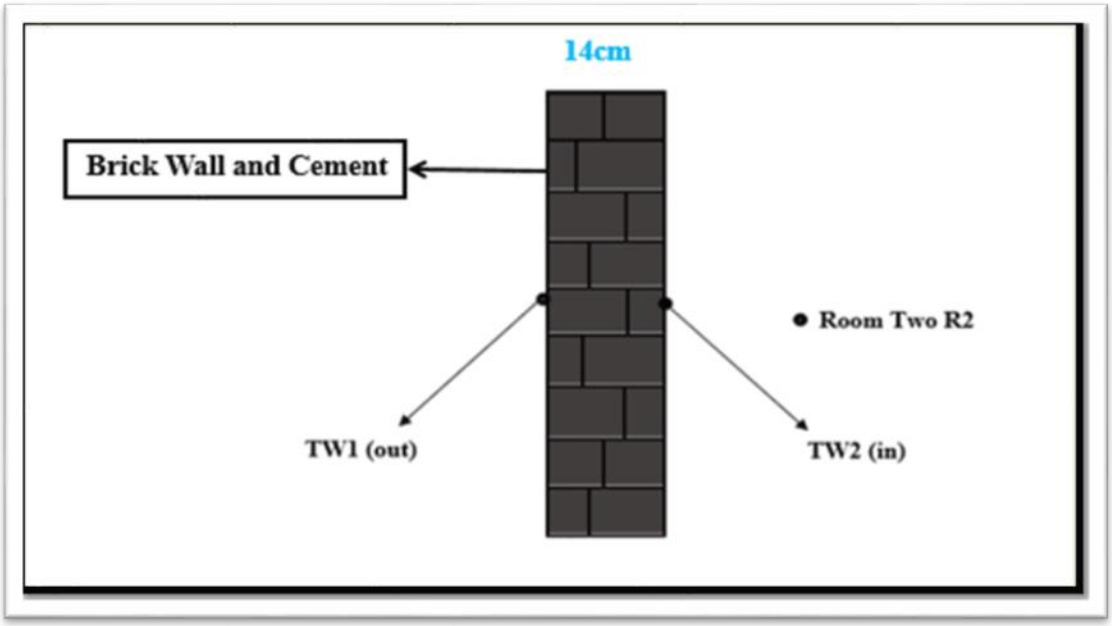


Figure .4.5. Wall brick and two layer of cement without air gaps .

4.4 Measurement of Temperature

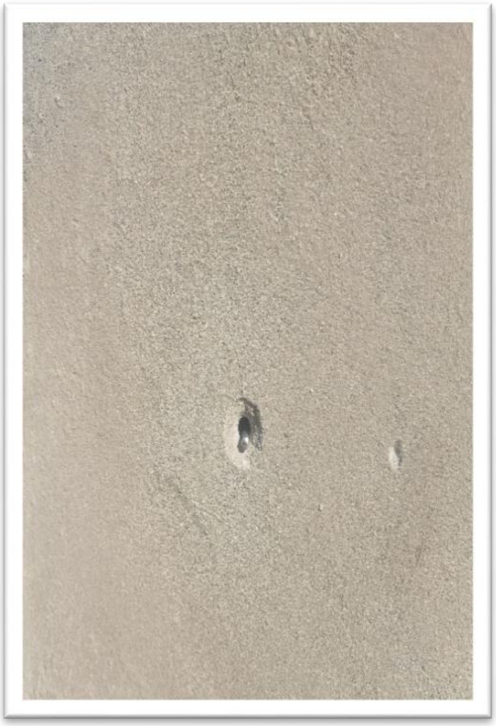
A type K (2M) thermocouple was used to measure external and internal temperatures of rooms. Figures 4.6 & 4.7 wires was laid on outer and inner walls of each surface with one in center of the room, insulated room contained 5 thermocouples, with outer and inner surface of cement wall with a package , as well as inner and outer wall package, distance between wires uniformly. A wire for measuring the temperature of external and internal walls shall be attached to wire in middle of room to measure room temperature. Room not insulated or not package ,contains 3 thermocouples. In addition to installing wire outside to measure temperature of outside ambient air .

`

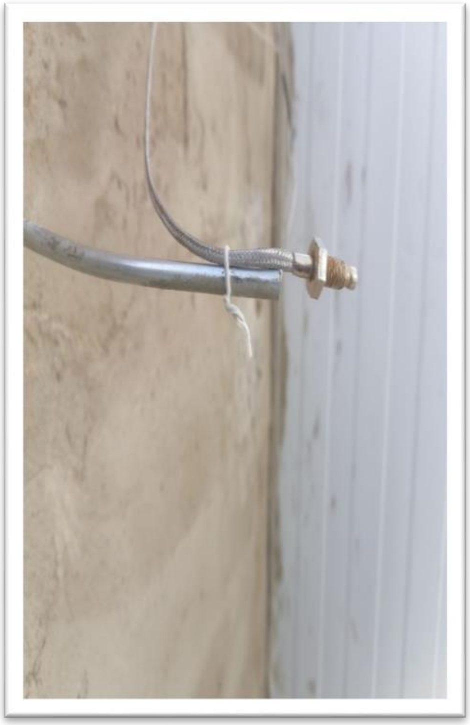
Wall alucobond outlet

Wall alucobond inlet

Wall cement intet

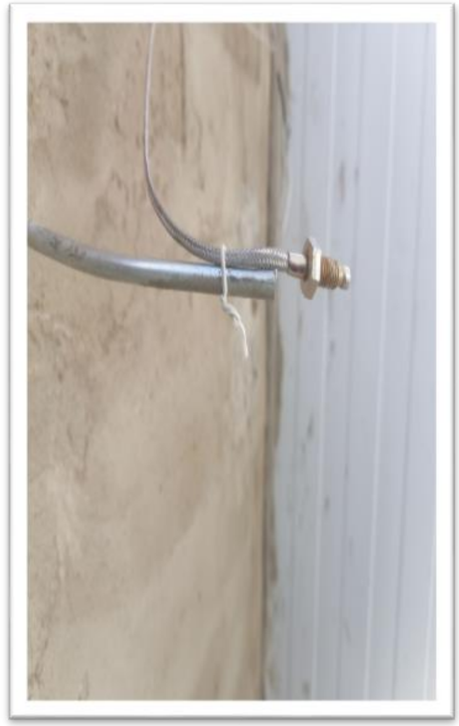


Wall cement outlet



Temperatuer ambient in room

Figure.4.6 show installation of thermocouple on the outer and inner walls insulation room.



Wall cement outlet Wall cement intet Temperatuer ambient in room

Figure.4.7 show installation of thermocouple on the outer and inner walls without insulation room.

4.4.1 Data Logger Temperature

The data logger model employed in this study comprises 32 input channels, and those input channels were used to measure temperature data show figure 4.8. measuring temperature of buildings walls inside and outside surfaces cement measuring temperature of room as well as indoor and outdoor air temperature of outer and inner insulating layers was also recorded following winter heating operation. Applet (AT-4532) model, 32 channels. Type K and type T thermocouples are employed by device Reading precision (0.2% + 1°C).

Figure .4.8. Applent Data Logger Thermometer (AT-4532) .

4.4.2 Thermocouple Temperature

Model used to measure room temperature contained temperature thermocouples in various places. Thermocouples of type K are employed figure 4.9. The logger data device is attached to these thermocouples, This thermocouple which often functions as temperature sensor with display instruments and electronic recording equipment, can monitor solid surface temperature of manufacturing processes ranging from (0 to 400 °C). The accuracy of this kind of thermocouple is very high (± 0.4%).

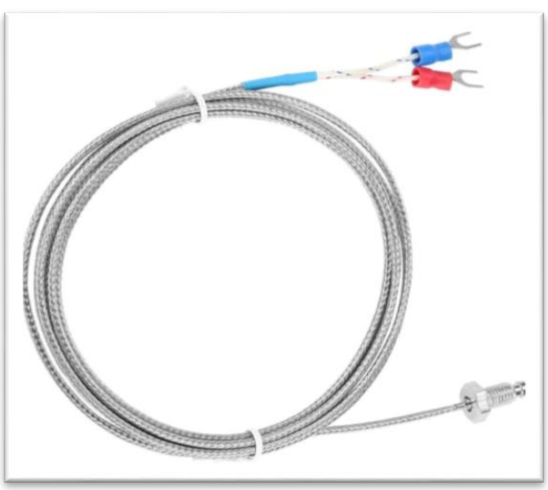


Figure .4.9. Thermocouples Type K.

4.5 Heating Unit

Heater unit model (JX-10156) which uses unit heater, heater unit capacity (1500W) maintains constant temperature of approximately 25°C in room model. Connected to thermocouple to regulate room temperature, the dimensions of the chambers (1.5m x1.5m) used show Figure 4.10.

Figure 4.10.Heater unit model sunny (JX-10156) and thermocouple to regulate temperatuer.

4.6 Summary

1. The site of examination room at Technical College of Engineering in Najaf .

2. Test were during winter in January and February and all tests start from 10 am to 5 pm and 8 hours during the day.

3. experiments work All were performed on cement wall, brick and south packaging wall at the same time for comparison.

4. Test was carried out by measuring temperature of interior and exterior walls of the room continuously for 8 hours, as well as measuring temperature of indoor and outdoor air.

5. In addition to measuring the temperature of outer and inner sheathing wall is alucobond insulating layer compared to brick wall without sheathing.

6. Experimental tests were carried out when the sky was clear.

7. Use heater unit capacity (1500W) maintains a constant temperature of approximately 25°C in room**.**

8. Air gaps (8, 5 and 2.5 cm) were used between alucobond insulating layer and concrete main wall. The idea of using an air gap was to provide a space in which the air used for purpose of heating and cooling moved.

9. An experimental test of insulated and non-insulated southward walls was carried out.

10. Temperature all distribution data over time was plotted using Microsoft Excel.

Table . 1. Properties of materials used in construction of the room.

Materials	**Thickness cm**	**Conductivity Thermal w/m °c**	**Density kg/m^3**
Brick	12	0.54 [27]	1900 [27]
Cement	1	0.32 [27]	2500 [27]
Air gaps	8,5&2.5	0.026 [28]	1.29 [28]
Alucobond	0.4	0.15 [29]	35 [29]
Sendwich panel	5	0.034 [29]	40 [29]

`

CHAPTER FIVE

RESULTS

AND DISCUSSIONS

`

CHAPTER FIVE

RESULTS AND DISCUSSIONS

5.1 Introduction

Experimental and theoretical results of recent work are included in this chapter. Evaluation of thermal performance of the insulator as it was used to build the outer wall of experimental model, and study was conducted in January and February and wall was facing south. Results show the distribution of wall temperature, solar, air temperature, insulated and non-insulated wall temperature, and heating load across the walls. Numerical results were calculated using ANSYS software.

5.2 Experiment Results

The practical aspect was divided into two parts, the cement wall without insulation and the cement wall with an insulating layer to cover outer wall of the room. The results and effect of heat distribution on the external and internal walls and heat loss through walls of the room are discussed, wall to south direction.

5.2.1 Distribution of Temperature (Season Winter)

The symbols indicate follow

T_{FW1} = Temperature of alucobond wall external face .

T_{FW2} = Temperature of alucobond wall internal face .

T_{FW3} = Temperature of brick external wall face alucobond.

T_{FW4} = Temperature brick of internal wall face alucobond .

T_{W1} = Temperature brick wall external face without alucobond..

T_{W2} = Temperature brick wall internal face without alucobond.

T_{Air} = Temperature of ambient air.

Figure 5.1 Shows temperature distribution of brick, cement wall without insulating layer, and wall in south direction. The outer ambient air temperature (Ta), the brick wall outer surface temperature (T_{w1}), and the brick wall inner surface temperature (T_{W2}). starts to rise during the day, reaches its peak around a specific time, and then falls to lowest point in evening, brick wall model with cement shows the temperature between the inner and outer surface of the wall. At 10 am, the difference in free degrees ΔT is about 11 °C, then increases to 18 °C at 2 pm. decreases Back to the minimum at 5 pm. With outside ambient air temperatures at 10am around 9°C, it then increases to a high of 16°C at 2 o'clock. It decreases again to a minimum at 5pm. The difference in temperature was very high because the cement wall is directly exposed to sunlight and heat gain process is fast, and because the cement's absorption of solar energy is high compared to temperature of outside environment, it was less because thermal capacity high of cement wall work winter.

Figure 5.2 shows alucobond insulation model showing temperature and distribution of brick and cement wall with the insulating layer and the south facing wall, as well as the air gap between the cement wall and the insulation (8 cm). For insulating layer wall ΔT between (T_{FW1} and T_{FW2}), temperature difference is very negligible in terms of heat gain, at 10 am 1 °C, and then increases to a maximum of 2 °C at 2 pm. Then it drops again to a minimum at 5 p.m. ΔT for a concrete wall with insulating layer T_{FW3}) and T_{FW4}), at 10 am 4 °C, then increases to a maximum of 7 °C at 2 pm. Then it drops again to a minimum at 5 p.m. Compared with the outside ambient air temperature at 10 a.m. 9°C, it then rises to a maximum of 16°C at 2 p.m. Then it drops to a minimum again at 5 pm with wind speed average through day (11 km/h). The drawing shows that the temperature of outside air is higher than temperature of concrete walls, and for several reasons, including the insulating layer that blocks solar energy and air from building wall, and the yellow color plays a role in reducing the temperature due to little absorption and high reflection, and therefore process of heat acquisition is very slow. Figures 5.1 and 5.2 ,Comparing can be seen that the maximum difference between the external and internal temperatures of cement wall was 18°C for wall, while the wall had the alucobond insulating layer at the same time 7°C, due to good thermal insulation because the insulating thermal conductivity is low.

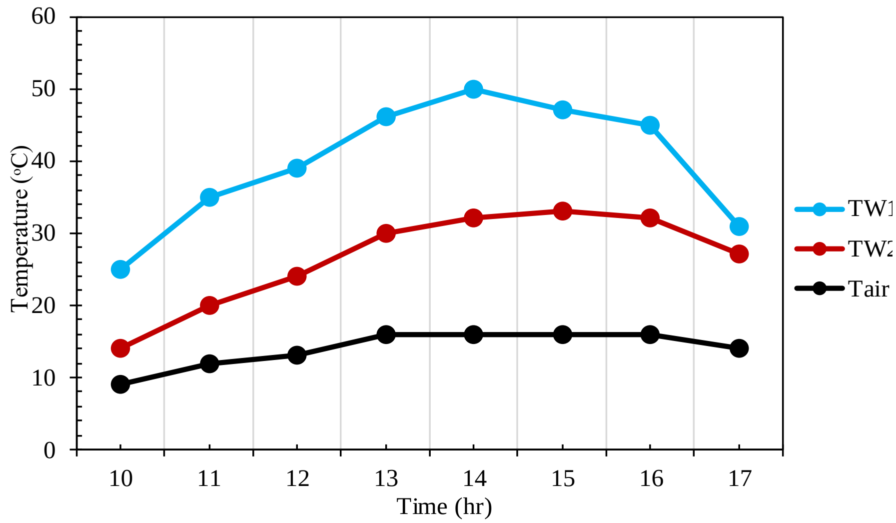


Figure 5.1 Distribution temperature of cement wall with air temperatuer at January 1/23/2022.

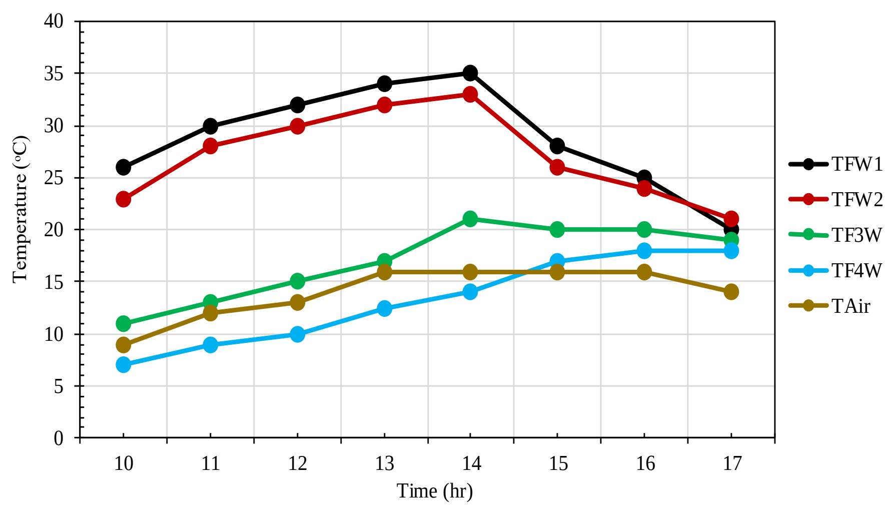


Figure 5.2 Distribution temperature of Alucobond wall with air temperature & air gap (8 cm) 1/23/2022.

`

Figure 5.3 shows temperature distribution of brick and cement wall without insulating layer and south facing wall. The temperature of outside ambient air (Ta) with temperature of outer surface of brick wall (T_{w1}), and the temperature of inner surface of the brick wall (T_{W2}). The rise begins during day, reaches its peak at a specific time, and then drops to its lowest point in the evening. brick wall model with cement shows the temperature between the inner and outer surface of wall. At 10 a.m., the difference in free degrees ΔT is about 10 °C, and then maximum rises to 17 °C at 2 pm, It decrease 5 p.m. With outside ambient air temperatures at 10 am around 13°C, it then rises maximum to 20°C at 2 pm. It decreases again to a minimum at 5 pm.

The temperature difference was very high because the cement wall is directly exposed to sunlight and the heat acquisition process is fast, and because the cement absorbs solar energy is high and also because of high heat capacity of cement wall, compared to the air temperature of external environment, however, we note an increase in the temperature of outside air This increase depends on amount of fallen solar radiation, work in winter.

Figure 5.4 shows the alucobond insulation model showing the temperature and distribution of the brick and cement wall with the insulating layer and the south facing wall, as well as the air gap between the cement wall and the insulation (5 cm). For insulating layer wall ΔT between (T_{FW1} and T_{FW2}), the temperature difference is very negligible in terms of heat gain, at 10 am 2°C, and then increases to a maximum of 3 °C at 2 pm. Then it drops again to a minimum at 5 p.m. ΔT for a concrete wall with insulating layer T_{FW3}) and T_{FW4}), at 10 am 3°C, then increases to a maximum of 3.5 °C at 2 pm. Then it drops again to a minimum at 5 p.m.

Compared with outside ambient air temperature at 10 a.m. 13°C, it then rises to maximum of 20 °C at 2 p.m. Then it drops to a minimum again at 5 pm with wind speed average through day (8.5 km/h). shows that temperature of outside air is higher than the temperature of the concrete walls, and for several reasons, including insulating layer that blocks solar energy and air from building wall, and yellow color play a role in reducing temperature due to little absorption and high reflection, and therefore process of heat acquisition is very slow.

`

Figures (5.3) and (5.4), comparing can be seen that the maximum difference between external and internal temperatures of the cement wall was 17 ° C for wall, while insulating layer at same time was 3.5 ° C, due to the good thermal insulation because the insulating thermal conductivity is low .

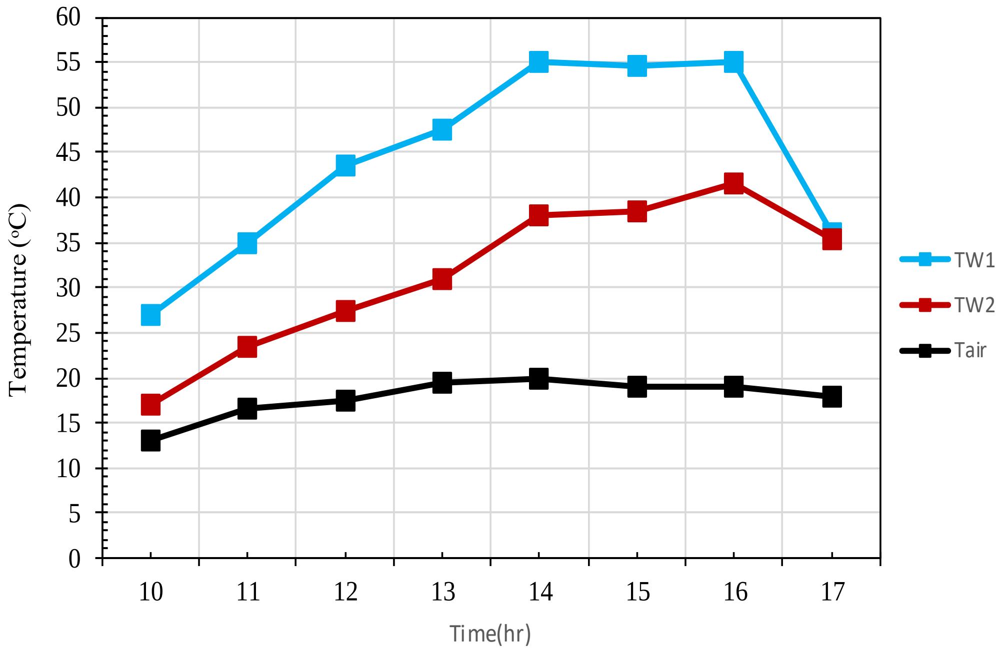


Figure 5.3 Distribution temperature of cement wall without air temperature 2/6/2022.

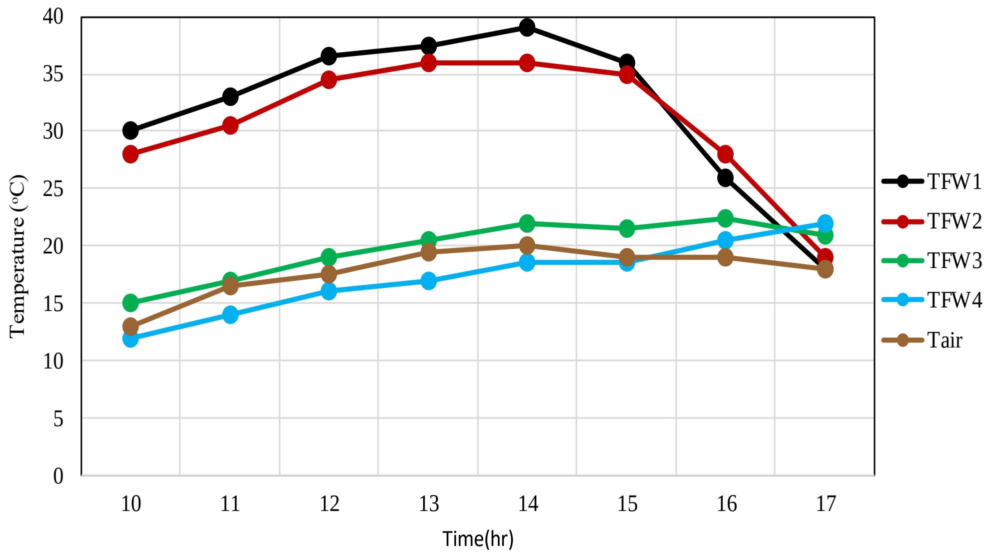


Figure 5.4 Distribution temperature of cement wall and alucobond wall with air temperature with air gap (5cm) 2/6 /2022

Figure 5.5 shows temperature distribution of brick and cement wall without insulating layer and south facing wall. Temperature of the outside ambient air (Ta) with the temperature of the outer surface of brick wall (T_{w1}), and temperature of inner surface of brick wall (T_{W2}). The rise begins during the day, reaches its peak at a specific time, and then drops to its lowest point in evening. The brick wall model with cement shows temperature between the inner and outer surface of wall. At 10 a.m., the difference in free degrees ΔT is about 9.5 °C, and then maximum rises to 17.5 °C at 2 pm, It decrease 5 p.m. With outside ambient air temperatures at 10 am around 19.5°C, it then rises maximum to 23.5°C at 2 pm. It decreases again to a minimum at 5 pm.

Figure 5.6 shows alucobond insulation model showing temperature and distribution of brick and cement wall with insulating layer and south facing wall, as well as air gap between cement wall and insulation (2.5 cm). For the insulating layer wall ΔT between (T_{FW1} and T_{FW2}), temperature difference is very negligible in terms of heat gain, at 10 am 2°C, and then increases to a maximum of 2.5 °C at 2 pm. Then it drops again to minimum at 5 p.m. ΔT for a concrete wall with insulating layer T_{FW3}) and T_{FW4}), at 10 am 3.5°C, then increases to maximum of 4.5 °C at 2 pm. Then it drops again to minimum at 5 p.m. Compared with outside ambient air temperature at 10 a.m. 19.5°C, it then rises to maximum of 23.5°C at 2 p.m. Then it drops to a minimum again at 5 pm with wind speed average through day (6.5 km/h).

The drawing shows that temperature of outside air is higher than the temperature of concrete walls, and for several reasons, including the insulating layer that blocks solar energy and air from the building wall, and yellow color plays role in reducing temperature due to little absorption and high reflection, and therefore process of heat acquisition is very slow, These panels reduce heat load.

Figures (5.5) and (5.6), comparing can be seen that maximum difference between the external and internal temperatures of the cement wall was 17.5 ° C for wall, while insulating layer at the same time was 4.5 ° C, due to the good thermal insulation because the insulating thermal conductivity is low.

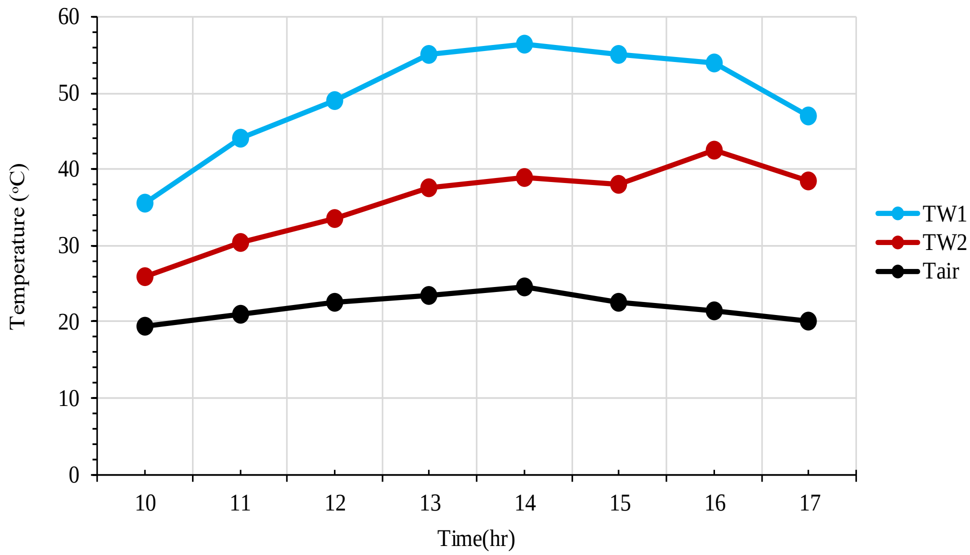


Figure 5.5 Distribution temperature of cement wall with air temperatuer 2022 /2/27.

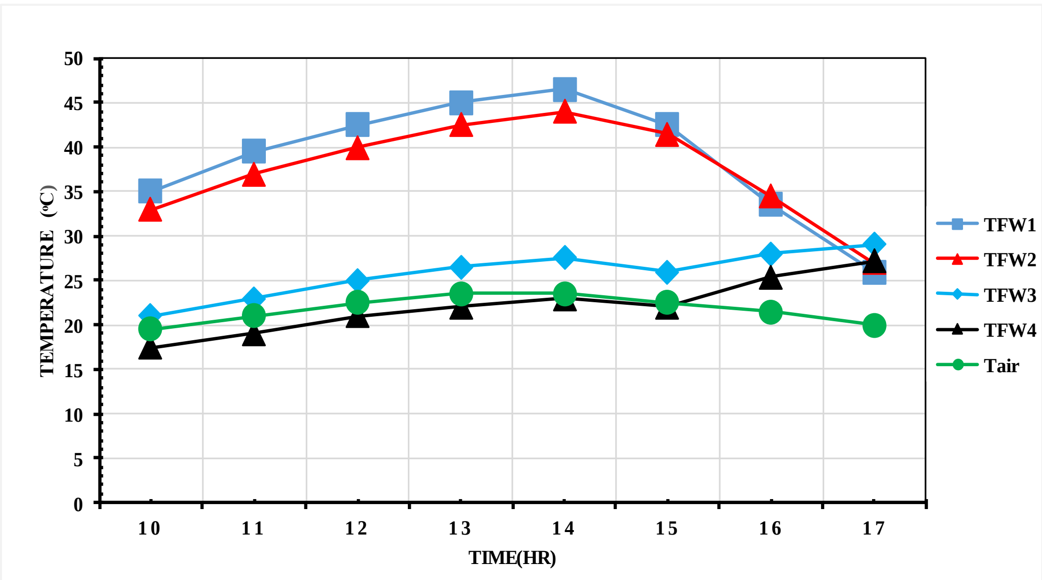


Figure 5.6 Distribution temperature of cement wall and Alucobond wall with air temperatuer with air gap (2.5cm) 2022 /2/27.

`

5.2.2 Heating Load Through Walls

Heating load is calculating from equation 3.10 and calculation energy save from equation 3.12 in chapter three.

Figure 5.7 Shows the rate of heat load and decrease through a brick and cement wall without insulation of concrete wall with alucobond and walls facing south. The negative sign indicates a decrease in heat, that is, heat goes out from the space to outside because insulated walls are not hot, but when the wall is heated, that is, heat comes from outside to inside presence with air gap (8 cm) The temperature of outside ambient air varies between (16-17 °C) at a temperature of Celsius, and the room is installed at temperature of 25 degrees Celsius, so it operates at temperature of (25°C).

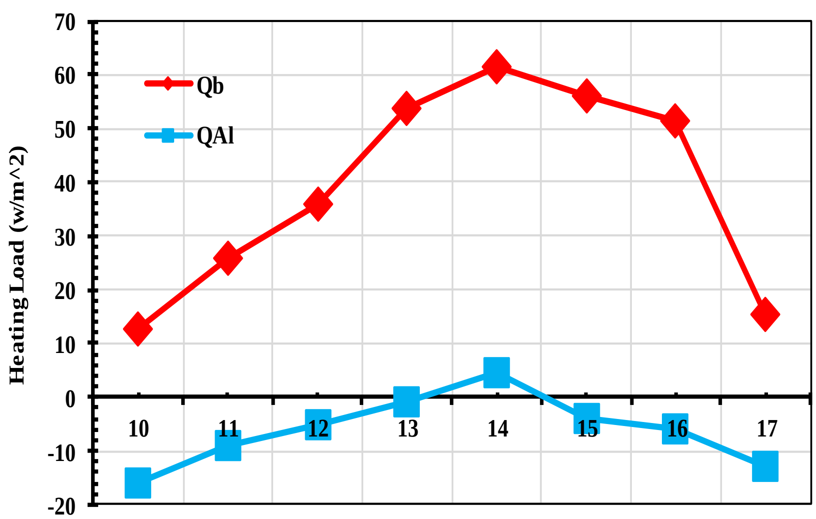


Figure 5.7 Heat load of cement wall and alucobond wall with air gap (8cm).

As for wall that is not thermally insulated, it heats up and the temperature of the wall is between (50-52) degrees Celsius, and the temperature inside the room is 25 degrees Celsius. Find that the heat comes from outside to inside. Then we notice a decrease in the non-insulating wall of heating load between (4-5 pm), due to high wind speed at this time reducing the heat (13 km / h). Comparing cement wall without cladding and cement wall with Alucobond , packaging highest heat loss value for unclad cement wall was (61.37 W/m^2) at 2 pm, and heat loss for cement wall with alucobond clad was (4.5 W/m^2) at 2 pm, so alucobond wall cladding gave energy savings (92%) at 2 pm.

Figure 5. 8 Shows rate of heat gain and decrease through a brick and cement wall without insulation of a concrete wall with alucobond and walls facing south. The negative sign indicates a decrease in heat, that is, the heat goes out from the space to outside because the insulated walls are not hot, but when the wall is heated, that is, heat comes from the outside to the inside the presence with air gap (5 cm). The temperature of ambient air varies between (20-21°C) at a temperature of the room is installed at a temperature of 25 degrees Celsius, so it operates at Celsius temperature of (25-21°C). As for the wall that is not thermally insulated, it heats up and the temperature of wall is between (55-58) degrees Celsius, and the temperature inside room is 25 degrees Celsius. Find that the heat comes from the outside to the inside. Then we notice decrease in the non-insulating wall of the heating load between (4-5 pm), due to the high wind speed at this time reducing heat (16 km / h). Comparing cement wall without cladding and cement wall with Alucobond , packaging the highest heat loss value for unclad cement wall was (76.73 W/m^2) at 2 pm, and the heat loss for cement wall with Alucobond clad was (-9.027 W/m^2) at 2 pm, so Alucobond wall cladding gave energy savings (88%) at 2 pm.

`

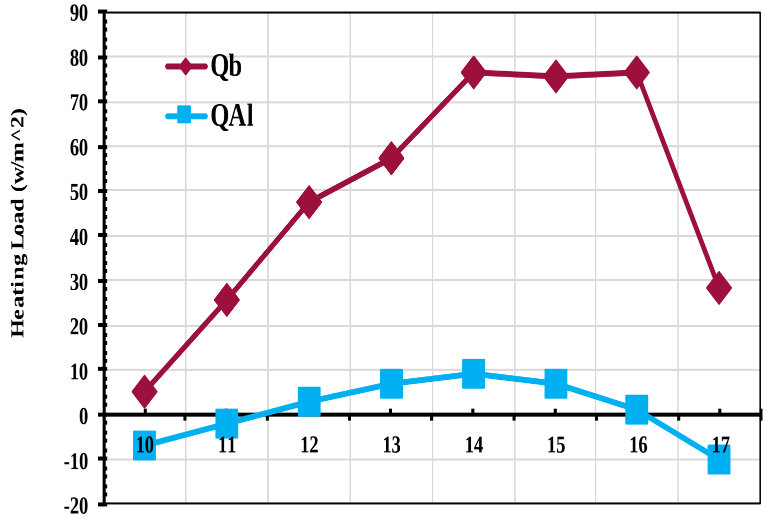


Figure 5.8 Heat load of cement wall and Alucobond wall with air gap (5 cm).

Figure 5.9 Shows the rate of heat gain and decrease through a brick and cement wall without insulation of concrete wall with Alucobond and the walls facing south. that is, the heat goes out from the space outside because insulated walls are not hot, but when the wall is heated, that is, heat comes from the outside to inside presence with air gap (2.5 cm) The temperature of outside ambient air varies between (23-24 °C) at a temperature of the room is installed at a temperature of 25 degrees Celsius, so it operates at a Celsius temperature of (25-24 °C). As for wall that is not thermally insulated, it heats up and the temperature of the wall is between (56.5-60) degrees Celsius, and temperature inside the room is 25 degrees Celsius.Find that the heat comes from outside to inside. Comparing the cement wall without cladding and cement wall with Alucobond , packaging the highest heat loss value for unclad cement wall was (80.55W/m^2) at 2 pm, and the heat loss for cement wall with alucobond clad was (21.465 W/m^2) at 2 pm, so alucobond wall cladding gave energy savings (73.352 %) at 2 pm.

`

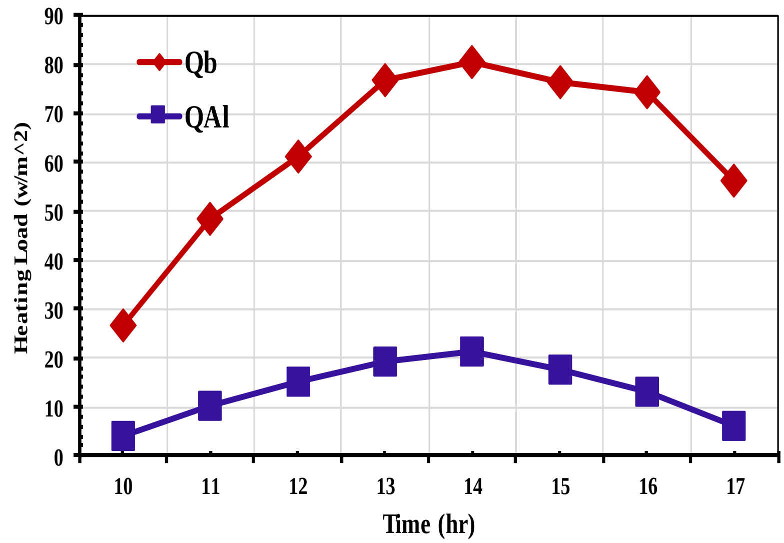


Figure5.9 Heat load of cement wall and Alucobond wall with air gap (2.5 cm).

5.2.3 Solar Energy and Heating Load

Figure 5.10 Shows significant effects of solar radiation on both heat gain and heat loss for building walls. We compare solar energy and heating load over time, between exterior and interior brick walls and cement wall with alucobond wall. The presence of an air gap (8 cm) between the wall of room and wall of the insulator improves or reduces heat gain, and in this case we note that solar radiation falling on alucobond wall is higher than the heat that passes through it, because the main source of heat is sun. The reason is that insulating jacket blocks sunlight and wind speed, which means that it blocks the inside from outside (heat works in opposite direction) because in winter, temperatures of insulated walls are low because the sun is blocked from wall and this wall receives heat only as result of convection, Because wall traps heat with absorption. The insulated wall, heat gain process is very little, because the solar radiation does not fall directly on it.

In addition to the very high reflectivity of alucobond, because the insulator used is polished, and the surfaces are shiny, which helps to reflect falling solar radiation, and therefore there is very little thermal storage of the material. The mass of the alucobond is small, so it gives a little time delay due to the less heat storage of the alucobond, and yellow color reduces heat falling on it. at 10 am the solar energy value is (6.44 W/m^2) and there is time delay due to wall absorbing transient heat also at 10 am (-16.048 W/m^2).Then value of solar energy rises with the rise in the heat load, then the amount of transient heat begins to decrease with rise of solar energy, and therefore because the sun is source of heat, up to a maximum at 12 pm (9.39 w/m^2) o'clock with heating load at 2 pm (4.5 w/m^2), then The amount of heating load decreases and Solar power on the wall at 5 pm o'clock. The wall is located in south direction because the best facing in the direction is south facade which receives small amount of solar radiation of 550W/m^2, which balances out amount of energy building receives.

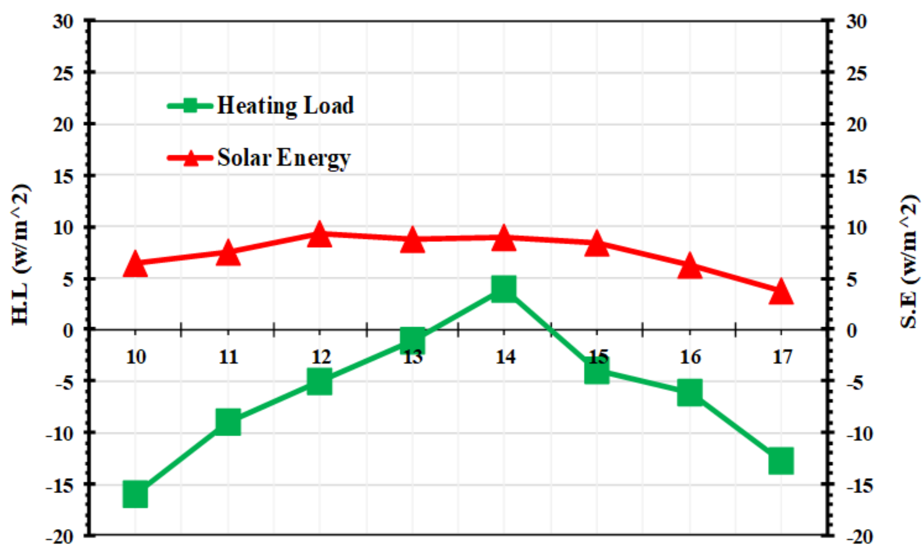


Figure 5.10 Show compare solar energy and heating load walls with alucobond wall with air gap (8 cm).

Figure 5.11 Shows significant effects of solar radiation on both heat gain and heat loss for building walls. We are comparing solar energy and heating load over time, between exterior and interior brick and concrete walls and wall without alucobond packaging . The value of general hheat flux (1000 Watts / m^2) falls into (1m^2) amount of heat falling on outer walls of room. In general, part is absorbed and part is reflected. And the temperature of external walls is directly exposed to the sun without insulation, because wall is built of brick and cement and it has a high ability to absorb solar energy falling on it, and also wall used grey-colored cement, percentage of reflection is very low, so falling solar energy on wall will be absorbed more than its reflection. Temperatures of external and internal walls of cement are high because heat enters walls from the outside to inside.

At 10 am solar energy (6.44 W/m^2) with heat passing through wall also at 10 am (12.8 W/m^2). Then value of solar energy to maximum at 12 pm (9.39 W / m^2) with heating load at 2 pm (61.37 W / m^2), then the decrease in amount of solar energy and amount of convection on the wall at 5 pm . Because of the high absorption of cement wall that works to store heat falling on it, because the wall does not transfer heat instantaneously, so it works to collect heat inside wall (heat storage), and therefore the stored heat crosses the wall and not heat transmitted from solar radiation. Thus, we note that large difference between amount of transient heat is higher than the amount of falling heat because wall stores heat inside, in addition to the high heat capacity of cement (0.9 kJ/kg.k).

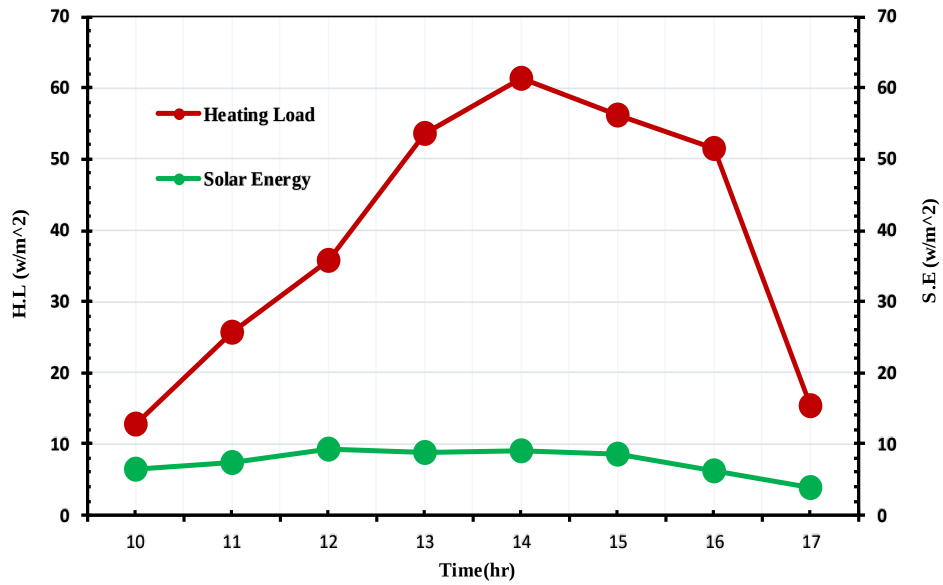


Figure 5.11 Show comparing solar energy and heating load walls without alucobond wall.

Figure 5.12 Shows significant effects of solar radiation on both heat gain and heat loss for building walls. We compare solar energy and heating load over time, between exterior and interior brick walls and cement wall with alucobond wall. The presence of an air gap (5 cm) between wall of room and wall of insulator improves or reduces heat gain in building , greater thickness of air gap, lower the amount of heat gain and vice versa and in this case we note that solar radiation falling on the alucobond wall is higher than heat that passes through it, because main source of heat is sun. The reason is that insulating jacket block sunlight and wind speed, which means that it block inside from outside (heat works in opposite direction) because in the winter, temperatures of the insulated walls are low because sun is blocked from wall and this wall receives heat only as result of convection, Because wall traps heat with absorption. and insulated wall, the heat gain process is very little, because solar radiation does not fall directly on it.

`

In addition to very high reflectivity of alucobond, the insulator used is polished, and surfaces are shiny, which helps to reflect falling solar radiation, and therefore there is very little thermal storage of material. The mass of alucobond is small, so it gives little time delay due to less heat storage of alucobond, and yellow color reduces the heat falling on it. at 10 am solar energy value is (7.7 W/m^2) and there is a time delay due to wall absorbing transient heat also at 10 am (-7.021W/m^2). Then the value of solar energy rises with rise in heat load, then amount of transient heat begins to decrease with rise of solar energy, and therefore because sun is source of heat, up to a maximum at 12 pm (11.156 w/m^2) o'clock with heating load at 2 pm (9.027 w/m^2), then The amount of heating load decreases and Solar power on the wall at 5 pm o'clock.Then we notice a decrease in non-insulation wall of the heating load between (4-5 pm), due to high wind speed at this time reducing the heat (16 km / h).

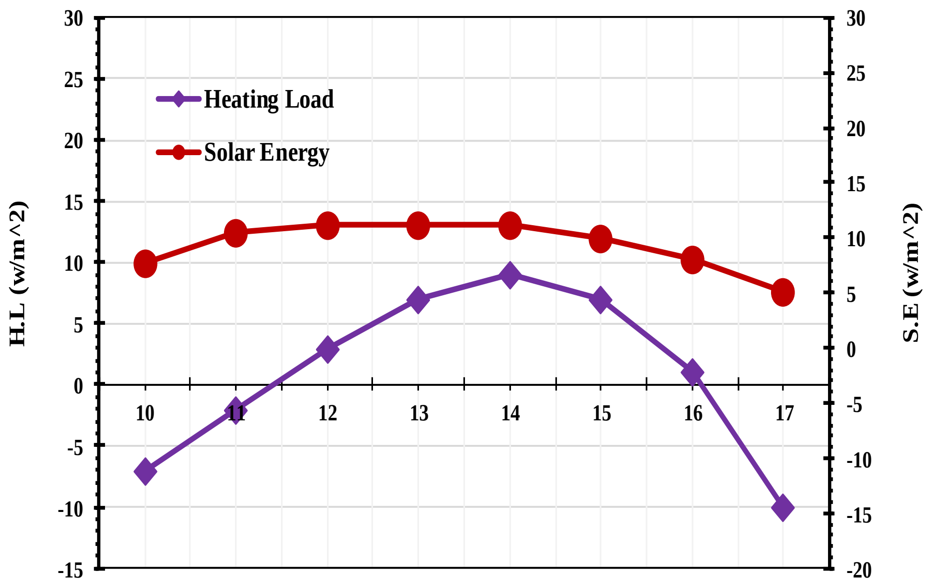


Figure 5.12 Show compare solar energy and heating load walls with alucobond wall with air gap (5 cm).

Figure 5.13 Shows significant effects of solar radiation on both heat gain and heat loss for building walls. We are comparing solar energy and heating load over time, between exterior and interior brick and concrete walls and wall without alucobond packaging . The value of general solar radiation (1000 Watts / m^2) falls into ($1m^2$) the amount of heat falling on outer walls of the room. In general, part is absorbed and part is reflected. And temperature of the external walls is directly exposed to the sun without insulation, because the wall is built of bricks and cement and it has a high ability to absorb solar energy falling on it, and also the wall used grey-colored cement, the percentage of reflection is very low, so falling solar energy on the wall will be absorbed more than its reflection. The temperatures of external and internal walls of cement are high because heat enters walls from the outside to the inside. At 10 am solar energy (7.7W/m^2) with heat passing through the wall also at 10 am (5.114 W/m^2).

Then value of solar energy to the maximum at 12 pm (11.156 W / m 2) with heating load at 2 pm (76.73 W / m 2), then the decrease in the amount of solar energy and amount of convection on the wall at 5 pm . Because of the high absorption of cement wall that works to store heat falling on it, because wall does not transfer heat instantaneously, so it works to collect heat inside wall (heat storage), and therefore the stored heat crosses wall and not heat transmitted from solar radiation. Thus, we note that large difference between amount of transient heat is higher than amount of falling heat because the wall stores heat inside, in addition to high heat capacity of cement (0.9 kJ/kg.k).Then we notice a decrease in non-insulation wall of heating load between (4-5 pm), due to high wind speed at this time reducing heat (16 km / h).

`

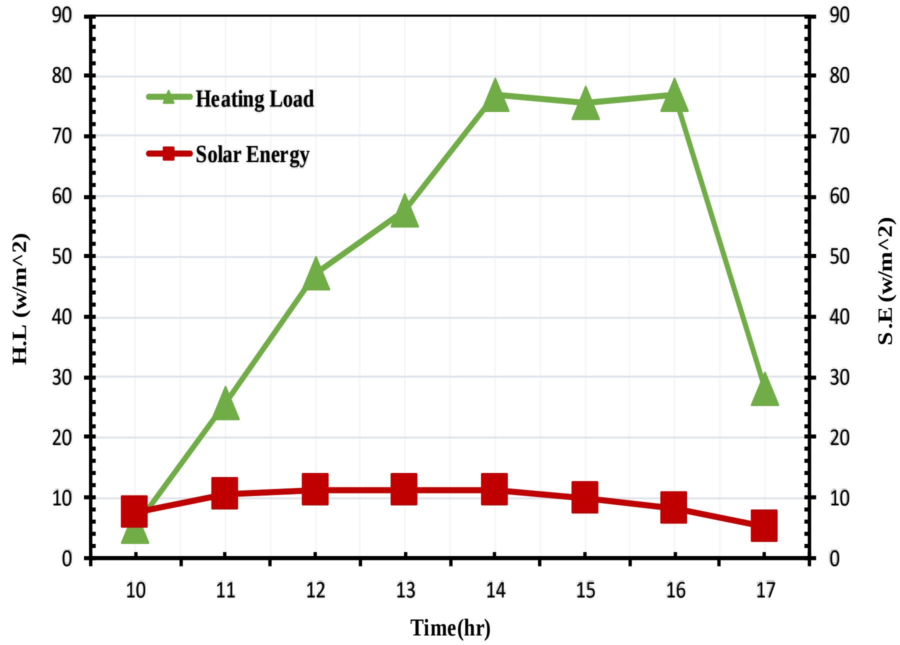


Figure 5. 13 Show compare solar energy and heating load walls without alucobond wall.

Figure 5.14 Shows significant effects of solar radiation on both heat gain and heat loss for building walls. We compare solar energy and heating load over time, between exterior and interior brick walls and cement wall with an alucobond wall. An air gap (2.5 cm) between the room wall and the insulating wall improves or reduces heat gain in the building. In general, solar radiation falling on a wall is higher than the heat that passes through it, because main source of heat is the sun. The reason is that insulating jacket blocks the sun rays and wind speed, which means that it blocks the inside from the outside, because in the winter, But in this case, we notice amount of heat passing through wall is higher than amount of heat falling on it, and therefore because when thickness of air gap decreases, the amount of heat transmitted or transiting through wall increases.

The heating load also increases with increase in the temperature of the outside ambient air. The amount of heat solar energy falling on a wall at 10 am is (7.93 W/m^2) with the amount of heat transient also at 10 am (4.012 W/m^2). Then the value of solar energy increases with heat load, maximum at 12 pm (13.455 W/m^2) with heating load at 2 pm (15.045 W/m^2), then amount of solar energy and heating load on wall decreases at 5 pm .

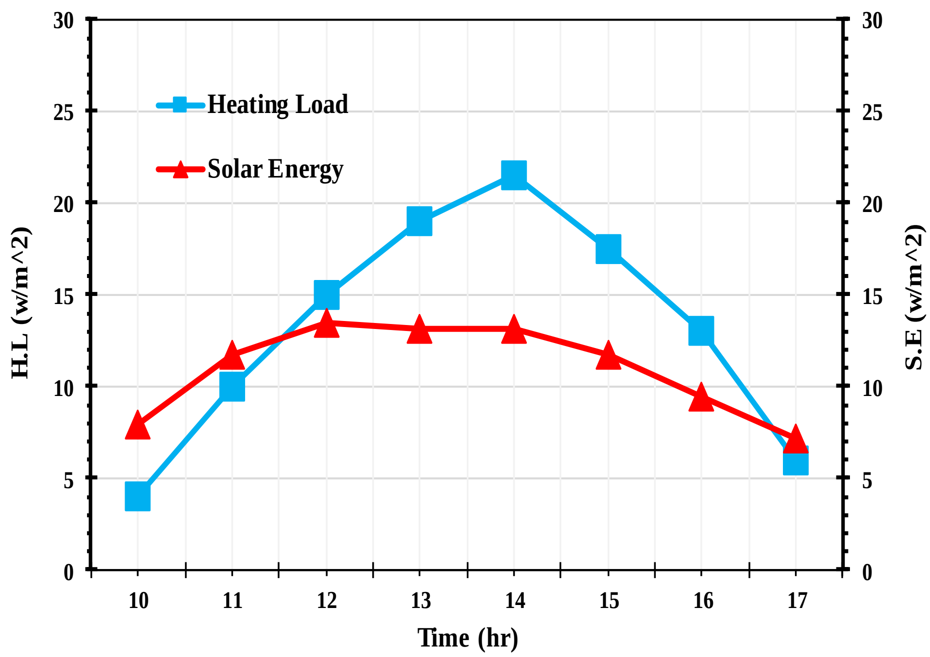


Figure 5.14 Show compare solar energy and heating load walls with alucobond wall with air gap (2.5 cm).

Figure 5.15 Shows significant effects of solar radiation on both heat gain and heat loss for building walls. We are comparing solar energy and heating load over time, between exterior and interior brick and concrete walls and wall without alucobond packaging . The value of the general solar radiation (1000 Watts / m^2) falls into ($1m^2$) amount of heat falling on the outer walls of the room. In general, part is absorbed and part is reflected. And the temperature of the external walls is directly exposed to sun without insulation, because wall is built of bricks and cement and it has high ability to absorb solar energy falling on it, and also wall used grey-colored cement, percentage of reflection is very low, so the falling solar energy on the wall will be absorbed more than its reflection.

The temperatures of external and internal walls of cement are high because the heat enters walls from the outside to inside. At 10 am the solar energy (7.39 W/m^2) with heat passing through the wall also at 10 am (26.85 W/m^2). Then the value of solar energy to maximum at 12 pm (13.445 W /m^2) with heating load at 2 pm (80.55 W /m^2), then decrease in the amount of solar energy and the amount of convection on wall at 5 pm . Because of high absorption of the cement wall that works to store heat falling on it, because wall does not transfer heat instantaneously, so it works to collect heat inside wall (heat storage), and therefore the stored heat crosses the wall and not heat transmitted from solar radiation. Thus, we note that large difference between the amount of transient heat is higher than the amount of falling heat because wall stores heat inside, in addition to high heat capacity of cement (0.9 kJ/kg.k).

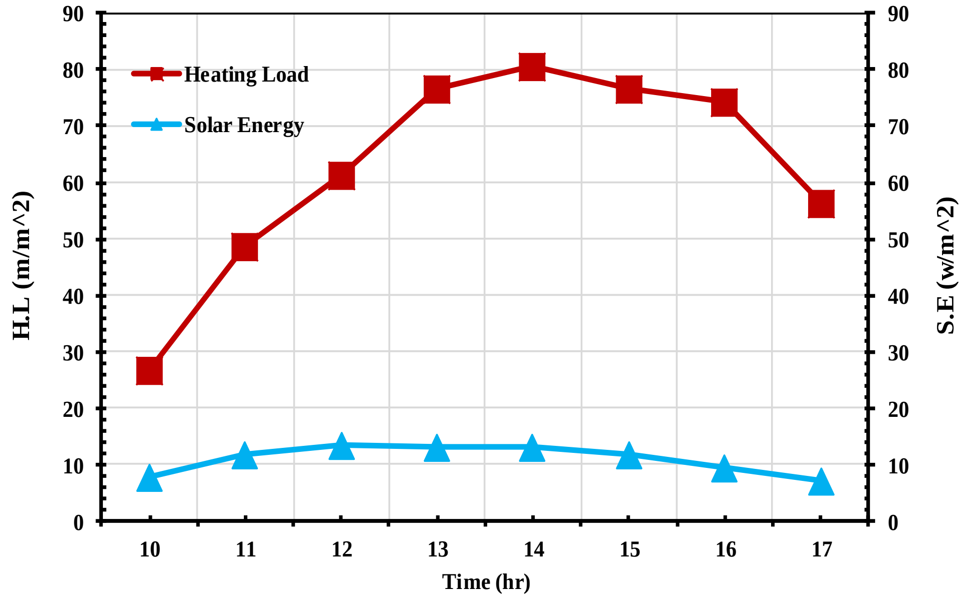


Figure 5. 15 Show compare solar energy and heating load walls without alucobond wall.

5.3 Numerical Results

The main objective of this study is to use several air gaps between main wall of room and packaging layer used alucobond, to take advantage them to provide a space in which air moves and is used for heating and cooling. The study was in the winter season, during January and February, and test wall was facing south, using ANSYS- FLUENT program .The pattern air flow and temperature distribution could be studied using path lines and contour result obtained from simulation. The simulation was carried out according to specifications prepared for current study. It explains difference and analysis in results obtained from the simulation for several air gaps, and these gaps act as thermal insulators.

`

In numerical results all that studied effect of ambient air temperature outer , solar radiation , temperature wall with layer alucobond and temperature wall without layer alucobond and effect air gaps between walls , input data used in simulation for (2022/1/23) were obtained from experimental data of experimental work present .

5.3.1 Temperature Distribution

Figure 5.16 shows temperature distribution of the main wall built of brick and concrete without the alucobond layer, and the wall is towards the south. The outside ambient air temperature (Ta) is combined with brick wall outer surface temperature (Tw_1), and the brick wall inner surface temperature (Tw_2). The rise begins during the day, reaches its peak at a specific time, and then drops to its lowest point in evening. The brick wall model with cement shows temperature between the inner and outer surface of the wall. At 10 am, difference temperature in ΔT is about 5 °C, then maximum rises to 10.5 °C at 12 noon , decreases 4 ^{o}C at 5 pm. With outside ambient air temperatures at 10am around 10.9°C, then rise to 18.5°C at 2pm. It drops again to a minimum 15.8 C at 5 pm. With room temperature constant at (25°C) all time due to using the heating unit. The temperature difference was very high because the cement wall is directly exposed to sunlight and heat gain process is fast, and also due to the high heat capacity of cement wall compared to outside ambient air temperature. However, we notice an increase in temperature of outside air, and this increase depends on amount of incoming solar radiation.

`

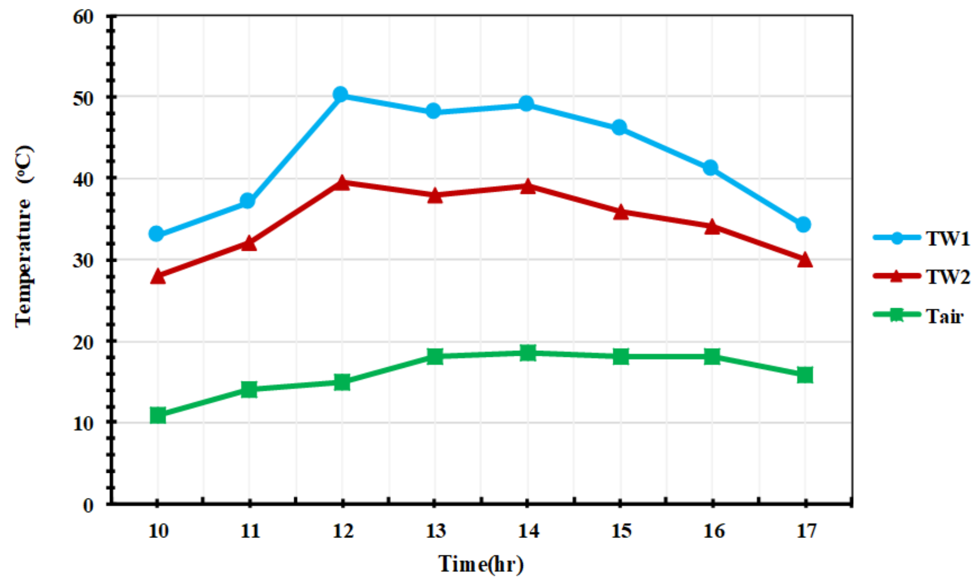


Figure 5.16 Temperature distribution of wall cement with temperature ambient air 1/23/ 2022.

Figure 5.17 shows Figure 5.20 shows alucobond insulation model showing the temperature distribution wall of brick and cement with the insulating layer and south facing wall, as well as the air gap between cement wall and the insulation (8 cm). Outer ambient air temperature (Ta), outer alucobond surface temperature (T_{FW1}), inner alucobond surface temperature (T_{FW2}), brick wall outer temperature (T_{FW3}) and brick wall inner surface temperature (T_{FW4}). For insulating layer wall ΔT between (T_{FW1} and T_{FW2}), temperature difference is very negligible in terms of heat gain, at 10 am 2 °C, then increases to a maximum of 1 °C at 2 pm. Then it drops again to a minimum 3C at 5 pm. ΔT for a concrete wall with insulating layer T_{FW3}) and T_{FW4}), at 10 am 3 °C, then increases to a maximum of 4°C at 2 pm. Then it drops again to minimum 3.5 ^{o}C at 5 pm. Compared with outside ambient air temperature at 10 a.m. 11.7°C, then rises to a maximum of 19.7°C at 2 pm.

Then it drops to a minimum again 16.3 °C at 5 pm. The drawing shows that temperature of outside air is higher than the difference in temperature of cement walls , Because air contacts the hot layer of packaging, its temperature increases and rises to top, with the presence of the air gap between the walls, reduces the heat load and acts as good thermal insulator due to low thermal conductivity of air 0.026 $W/m^2.°C$.

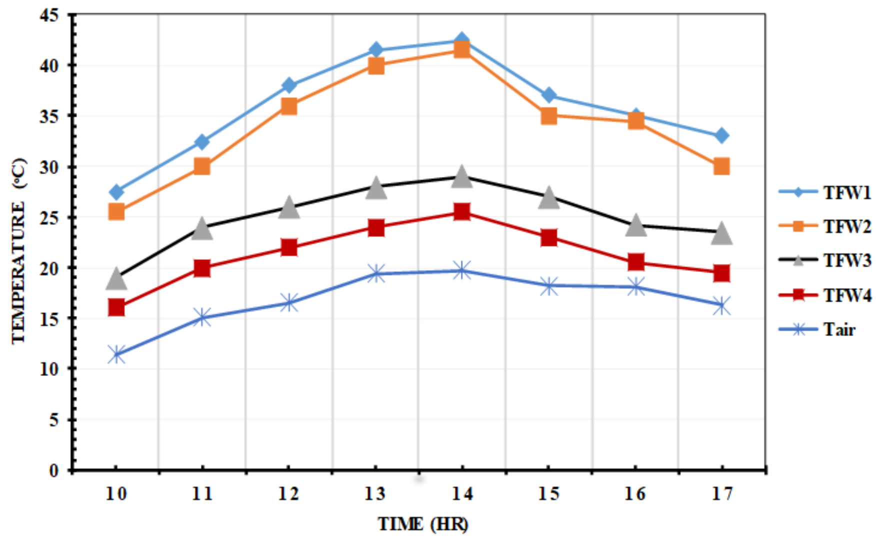


Figure 5.17 Temperature distribution of cement wall with air gap (8 cm) 1 /23/2022.

Figure 5.18 shows alucobond insulation model showing the temperature distribution wall of brick and cement with insulating layer and south facing wall, as well as air gap between the cement wall and insulation (5cm). For insulating layer wall ΔT between (TFW1 and TFW2), temperature difference is very negligible in terms of heat gain, at 10 am 3 °C, then increases to a maximum of 1.5 °C at 2 pm. Then it drops again to a minimum 3 C at 5 pm. ΔT for a cement wall with insulating layer (TFW3) and TFW4), at 10 am 3 °C, then increases to a maximum of 3.9°C at 2 pm. Then it drops again to a minimum 3 °C at 5 pm.

Compared with outside ambient air temperature at 10 a.m. 11.9°C, then rises to a maximum of 20.5 °C at 2 pm. Then it drops to a minimum again 18 °C at 5 pm. shows figure that the increase in temperature of ambient air outside, due to increase solar radiation, begins to increase at 10 am and peaks at 12 pm, after which it begins to decrease. Also, temperature of outside air is higher than the difference in temperature of cement walls, because the air touches hot layer of package, its temperature rises and rises to top, with an air gap between walls, which reduces heat load and acts as a good thermal insulator due to low thermal conductivity of air 0.026 Watt / m2, we notice that the smaller the air gap, the temperature of the room walls increases with increase in rate of air heating because it is easily heated by solar radiation, which causes an additional load on heating system in wall room.

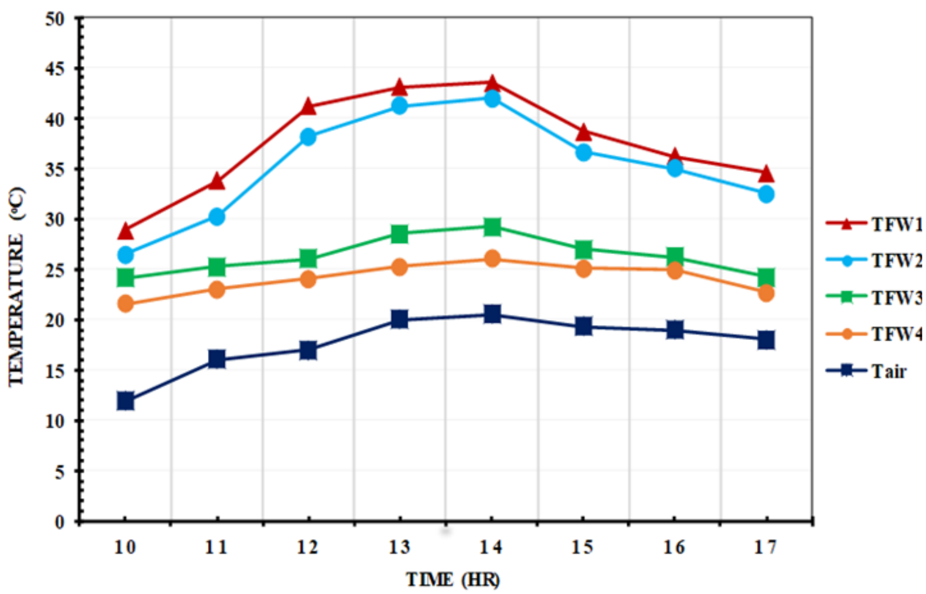


Figure 5. 18 temperature distribution wall room with air gap

(5cm) 1/23/2022

Figure 5.19 shows alucobond insulation model showing temperature distribution wall of brick and cement with insulating layer and south facing wall, as well as air gap between the cement wall and insulation (2.5 cm). Outer ambient air temperature (Ta), outer alucobond surface temperature (T_{FW1}), inner alucobond surface temperature (T_{FW2}), brick wall outer temperature (T_{FW3}) and brick wall inner surface temperature (T_{FW4}). For insulating layer wall ΔT between (T_{FW1} and T_{FW2}), temperature difference is very negligible in terms of heat gain, at 10 am 3°C, then increases to maximum of 2°C at 2 pm. Then it drops again to minimum 1.2 C at 5 pm. ΔT for cement wall with insulating layer (T_{FW3}) and T_{FW4}), at 10 am 3.2 °C, then increases to a maximum of 3 °C at 2 pm. Then it drops again to a minimum 2.9 ^{o}C at 5 pm. Compared with outside ambient air temperature at 10 a.m. 12 °C, then rises to maximum of 21.5 °C at 2 pm. Then it drops to minimum again 18.5 ^{o}C at 5 pm.

Figure shows that increase in ambient air temperature outside, due to increased solar radiation, begins to increase at 10 am and reaches its peak at 12 pm. after which it begins to decrease. It also shows thickness of the air gap 2.5 cm , this thickness is small so is easily heated by solar radiation, which causes an additional load on heating system in room. With an air gap between walls, we notice that smaller air gap, temperature of room walls increases, rate of air heating increases, in addition, solar radiation is stored in cement wall as reasonable energy to be used at night and vice versa.

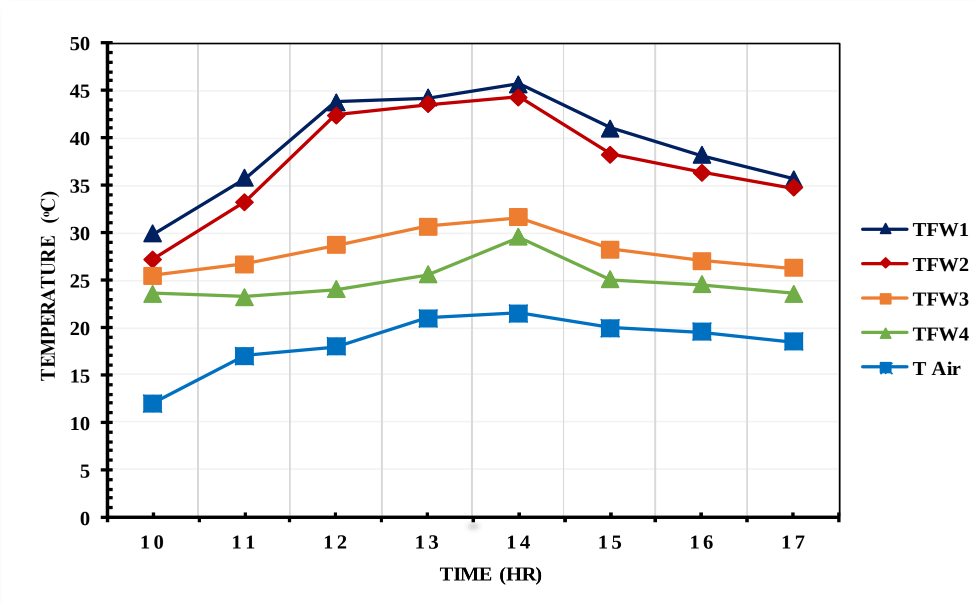


Figure 5.19 Temperature distribution of cement wall with air gap (2.5cm) 1/23/2022.

5.4 Distribution Temperature Study (wall room main)

Figures 5.20 & 5.21 Shows that main wall of the room is made of bricks and two layers of cement (14 cm thick), one wall without the covering layer and the other wall with an insulating layer of alucobond between them are air gaps (8.5 and 2.5 cm). The winter practical test period for each gap is (23-25 January 2022 10am-5pm). From February (6-8pm 10am-5pm). From February (27-28pm) From 10 am, to 5 pm, wall direction south.

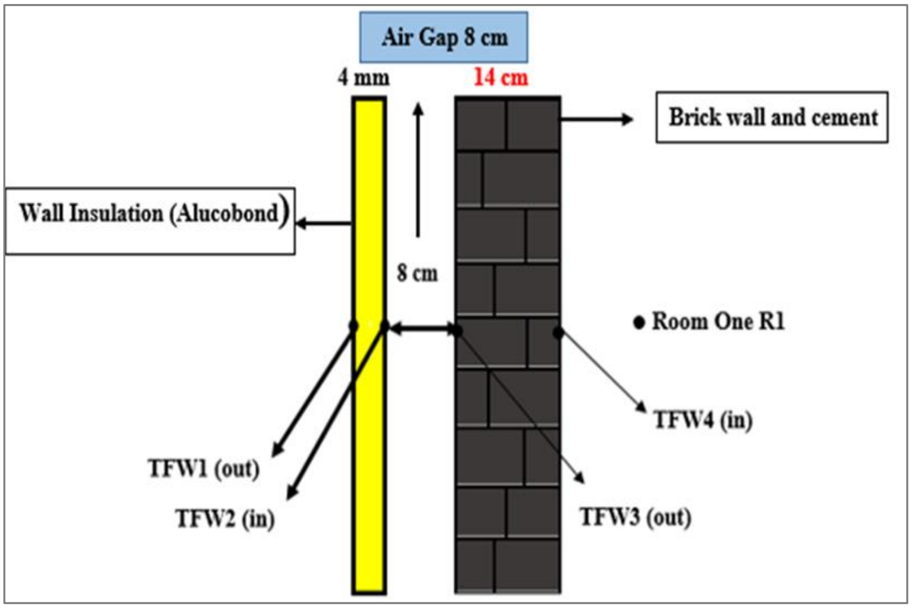


Figure 5.20 wall room main with air gaps (8,5&2.5).

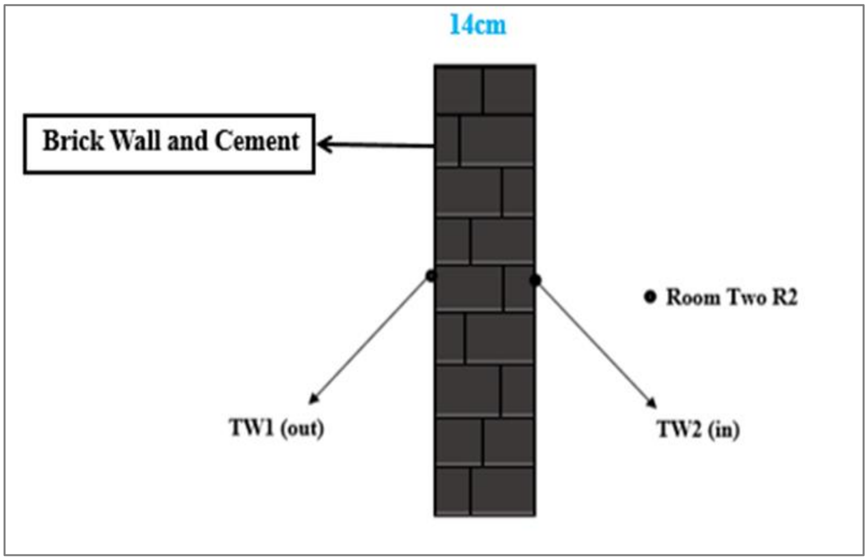


Figure 5.21 wall room main without air gap .

Figure 5.22 Shows contour temperature distribution through the main room wall, which is built of bricks of thickness (12 cm) and two layers of cement of thickness (1 cm), The rest of walls are adiabatic and wall is towards the south. The wall direction (XY) and symmetrical about the (Y) axis. The fall of sun rays on the wall of room in direction of (X) axis and perpendicular to middle of wall. The wall appears in red on the right side of figure, because the sun falls directly on the wall of room, and process of obtaining wall temperatures is very high, because there is no thermal insulation that reduces falling solar radiation. We take hours (10:10am , 12:10pm,2: 10pm & 4: 10) to find out who distribution of heating varies with temperature. We note that maximum range of wall temperatures is at 12:10 pm, because simulation results are steady state , because a wall stores energy and then transfers it. The highest temperatures are supposed to be at 2 pm, due to the program feeding solar the highest value at 12 pm, so the program will give the highest temperature at 12 pm, the rate is low at the entry port and high at the exit port because the hot air rises to top due to the buoyancy force as result (buoyancy effect) And blue color on left side represents outside ambient air, which is located near the wall of room, is governed by temperature of outside ambient air with wind speed. As for inside room, the temperature is constant at (25°C) with a convective heat transfer coefficient.

Figure 5.23 Shows distribution of contour temperature through wall of main room built of brick (12 cm thick) and two layers of cement thickness (1cm) with wall packing thickness (4 mm) with air gap thickness (8cm) between two walls and with ambient temperature . The rest of walls are adiabatic and wall towards the south. The wall is in direction (XY) and symmetrical about the (Y) axis. wall is shown in low temperature yellow on right side of figure, because the coating is reducing heat. We take hours (10:10 am, 12:10 pm, 2:10 pm & 4:10 pm) to see distribution of heating that varies with temperature over time, within one day of test. The sun rays fall on wall of room in direction of (X) axis and perpendicular to middle of wall. Note low temperatures of main wall of room because alucobond heat insulating package works to block sun rays and thus reduce temperature of cement wall. One of problematic points in design of wall room for current study is to choose optimal thickness of air gap .

`

The objective of numerical study is to find effect of thickness of air gap between room wall and packaging layer on thermal parameters of a wall in winter conditions in Najaf , Air movement and heat distribution through the room wall can also be investigated. add alucobond thermal conductivity is very low (0.15 $w/m^2.k$). generally because metallic material gains and loses heat faster than brick.

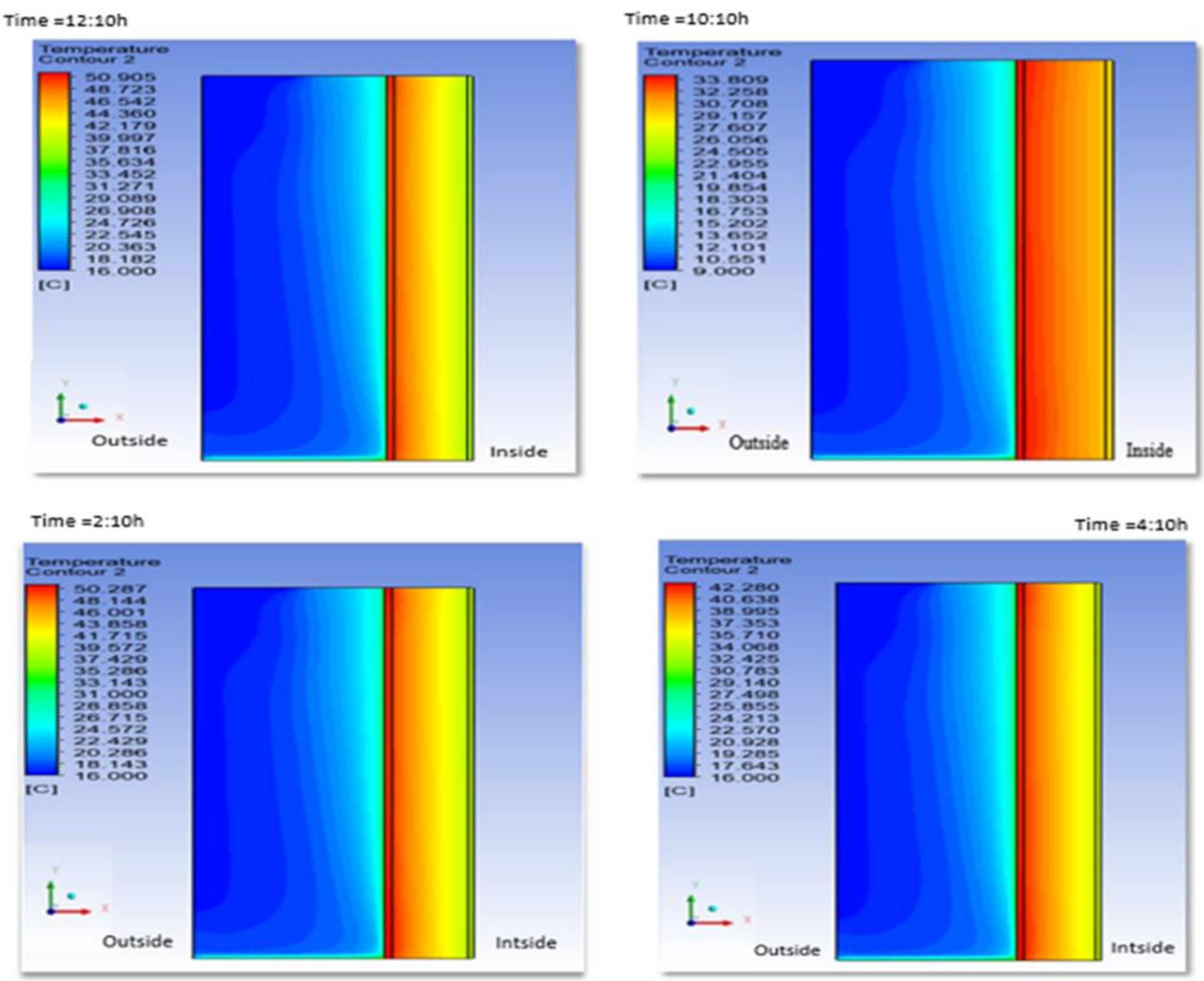


Figure 5. 22 Temperature distribution contour without air gap at 1/23/2022.

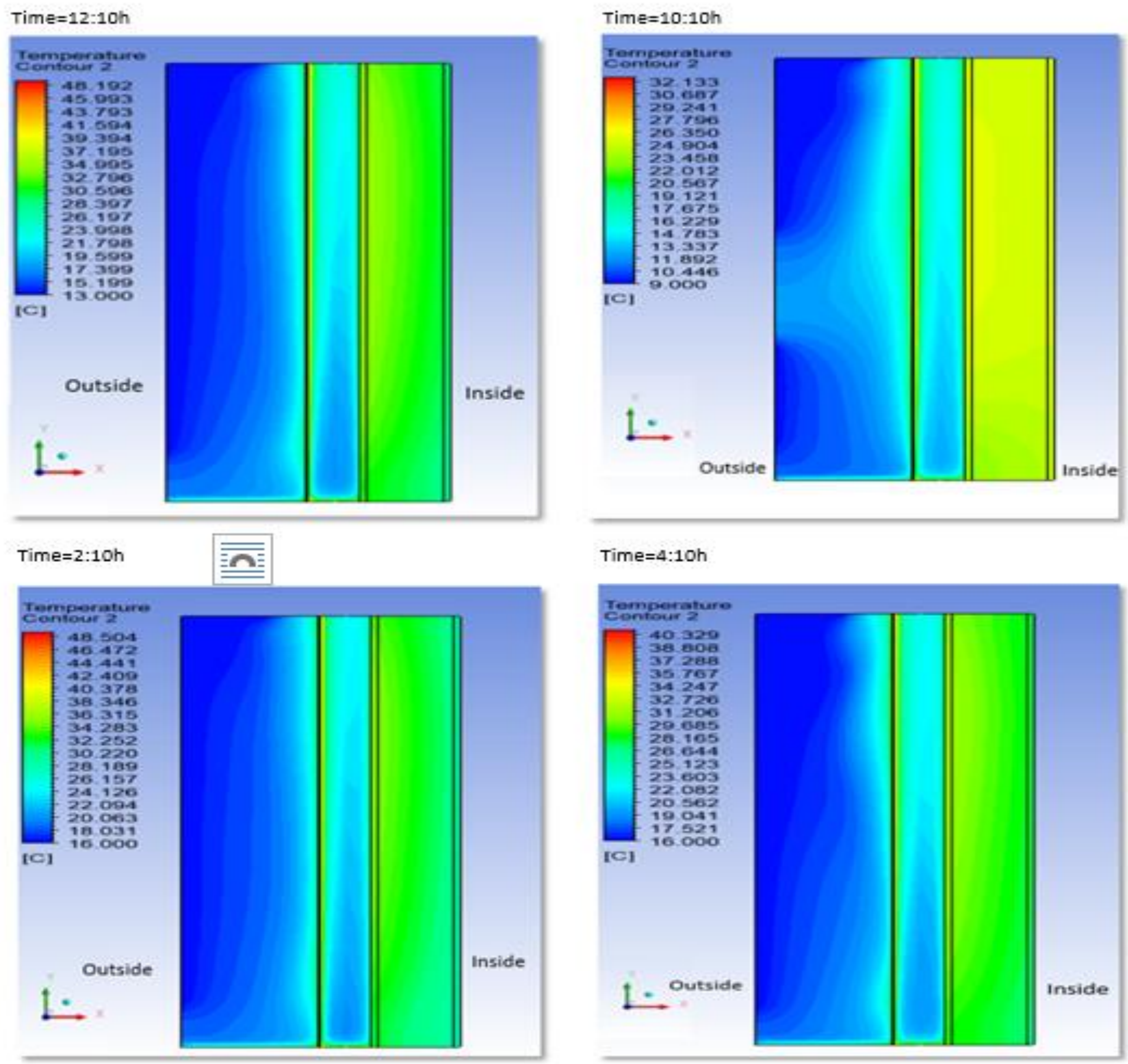


Figure 5.23 Temperature distribution contour with air gap (8cm).

Figure 5.24 shows distribution of contour temperature through wall of main room built of brick (12 cm thick) and two layers of cement thickness (1cm) with a wall packing thickness (4 mm) with air gap thickness (5 cm) between two walls at room temperature . Note from the displayed shapes, greater thickness of air gap, this led to an increase in the temperature distribution through the main wall of room.

The rest of walls are of constant temperature and the wall faces south. The wall is in the (XY) direction and symmetrical about (Y) axis. The wall appears green and yellow at lower temperature on the right side of the figure, because paint reduces heat. We take the hours (10:10 a.m., 12:10 p.m., 2:10 p.m. and 4:10 p.m.) to see distribution of heating that varies with temperature over time, within one day of testing. The sun rays fall on wall of the room in direction of the (X) axis and perpendicular to middle of the wall. We observe lower temperatures of main wall of room because alucobond thermal insulation package blocks sun rays and thus reduces temperature of cement wall.

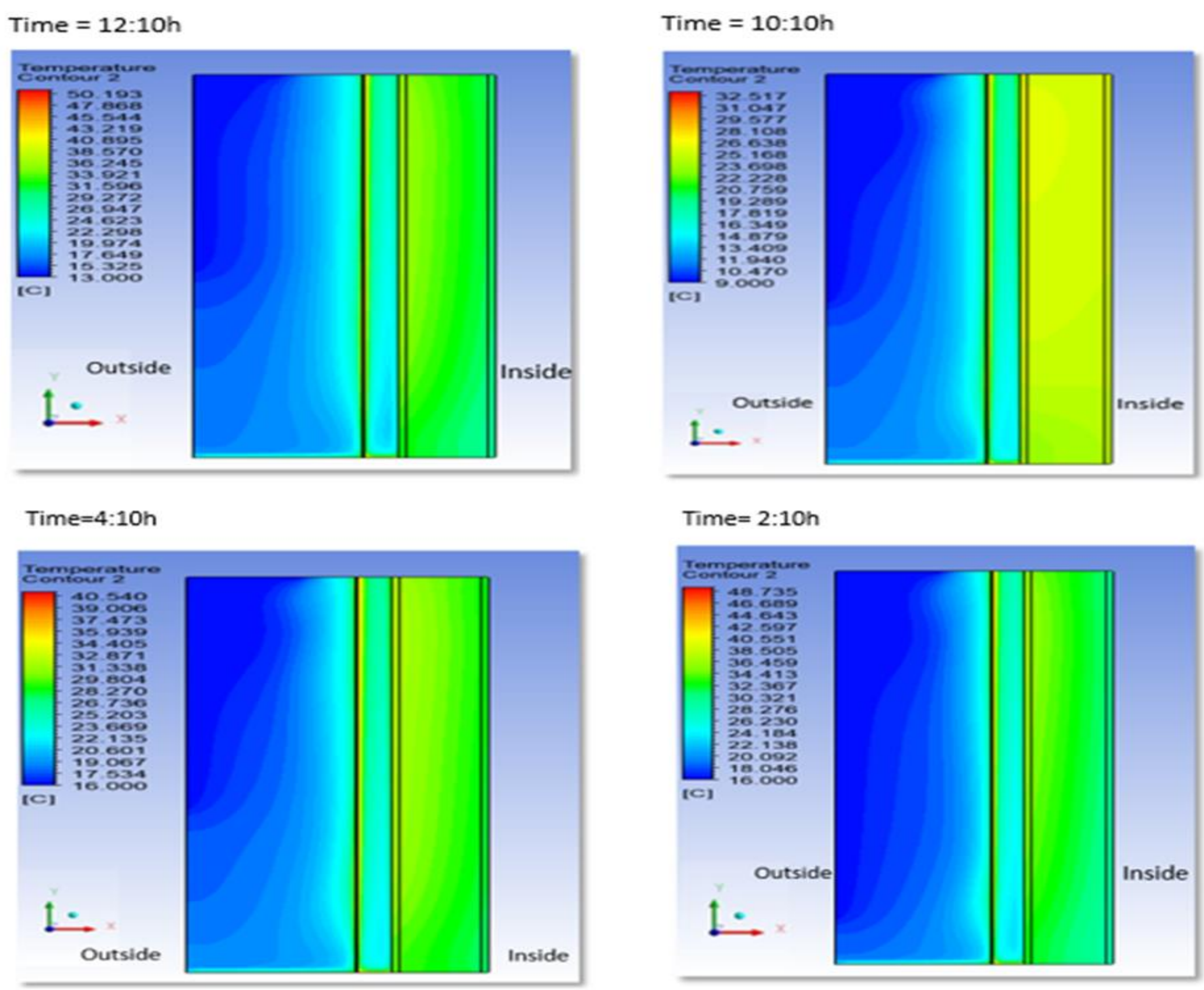


Figure 5.24 Temperature distribution contour with air gap (5cm).

`

Figure 5.25 Shows Distribution of contour temperature through wall of main room built of brick (12 cm) and two layers of cement (1 cm thickness) with a wall covering thickness (4 mm) with an air gap thickness (2.5 cm) between two layers of cement (1 cm) thick (4 mm) with an air gap (2.5 cm) between two walls at room temperature. We notice from the presented figures, smaller thickness of air gap, greater temperature distribution across main wall of room and it can be easily heated. The rest of walls are of constant temperature and wall faces south. Wall is in (XY) direction and symmetrical about the (Y) axis. The wall appears green and yellow at lower temperature on right side of figure, because paint reduces heat.

Take hours (10:10 am, 12:10 pm, 2:10 pm and 4:10 pm) to see distribution of heating that varies with temperature over time, within We note that maximum range of wall temperatures is at 12:10 pm, because simulation results are steady state , because a wall stores energy and then transfers it. The highest temperatures are supposed to be at 2 pm, due to the program feeding solar the highest value at 12 pm, so program will give highest temperature at 12 pm, rate is low at entry port and high at exit port because the hot air rises to top due to buoyancy force as a result (buoyancy effect) and blue color on left side represents outside ambient air, which is located near wall of room, is governed by temperature of outside ambient air with wind speed. As for inside room, temperature is constant at (25°C) with a convective heat transfer coefficient.

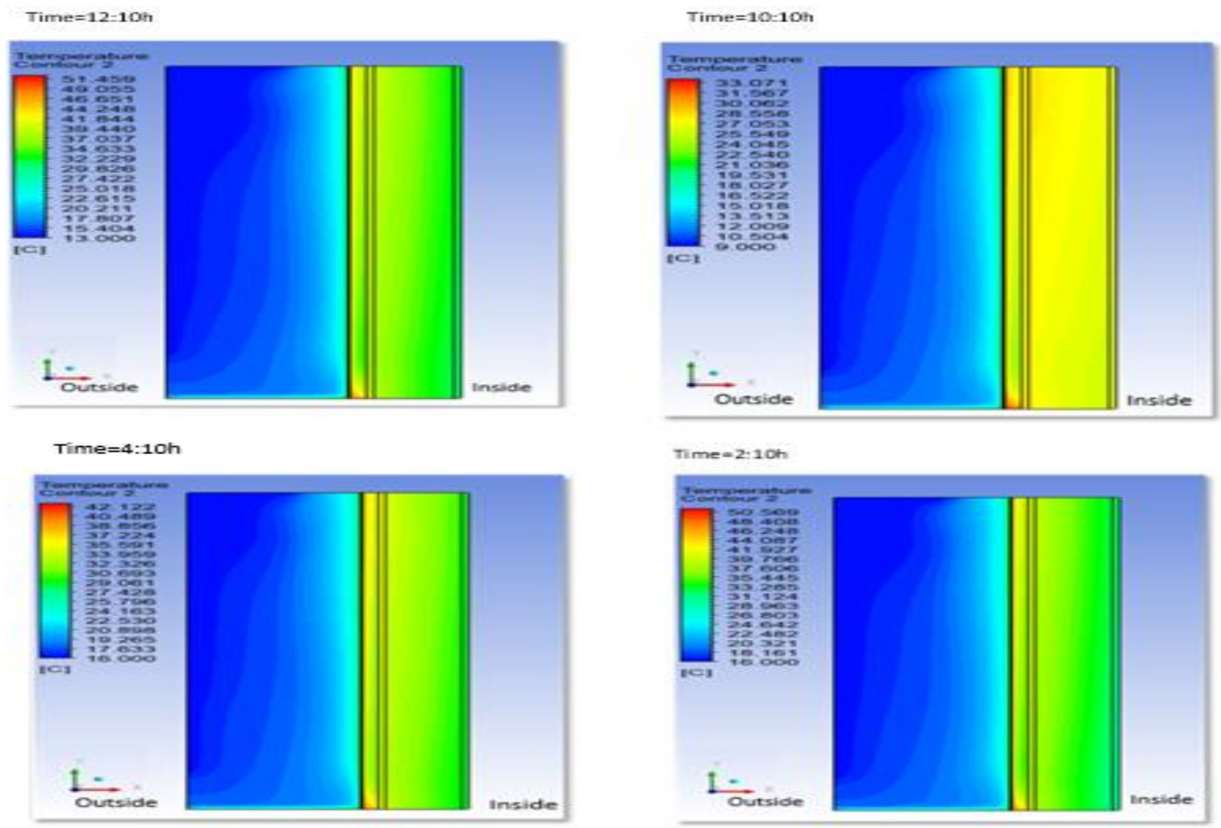


Figure 5.25 temperature distribution contour with air gap (2.5cm).

Figure 5.26 Shows the contour temperature distribution on alucobond wall layer with air gap, an air gap represents temperature variation in a room wall with an 8 cm thickness. In this situation, wall ability to distribute heat declines. Maximum air temperature, which was 19.7 ° C at the time, was also obtained. The amount of air that is constantly confined in the air gap grows as air gap , decreasing amount of heat gained. The outcome is a decrease in air temperature. and note that alucobond layer is hot, which heats cement wall, because this layer has a high temperature that acts as solar radiation on cement wall from face to face and thus face increases wall temperature Cement that is with the packing layer. We also note from air that surrounds alucobond layer is hot because it floats and heats up and rises to top and hot air comes out from top and works as a solar chimney.

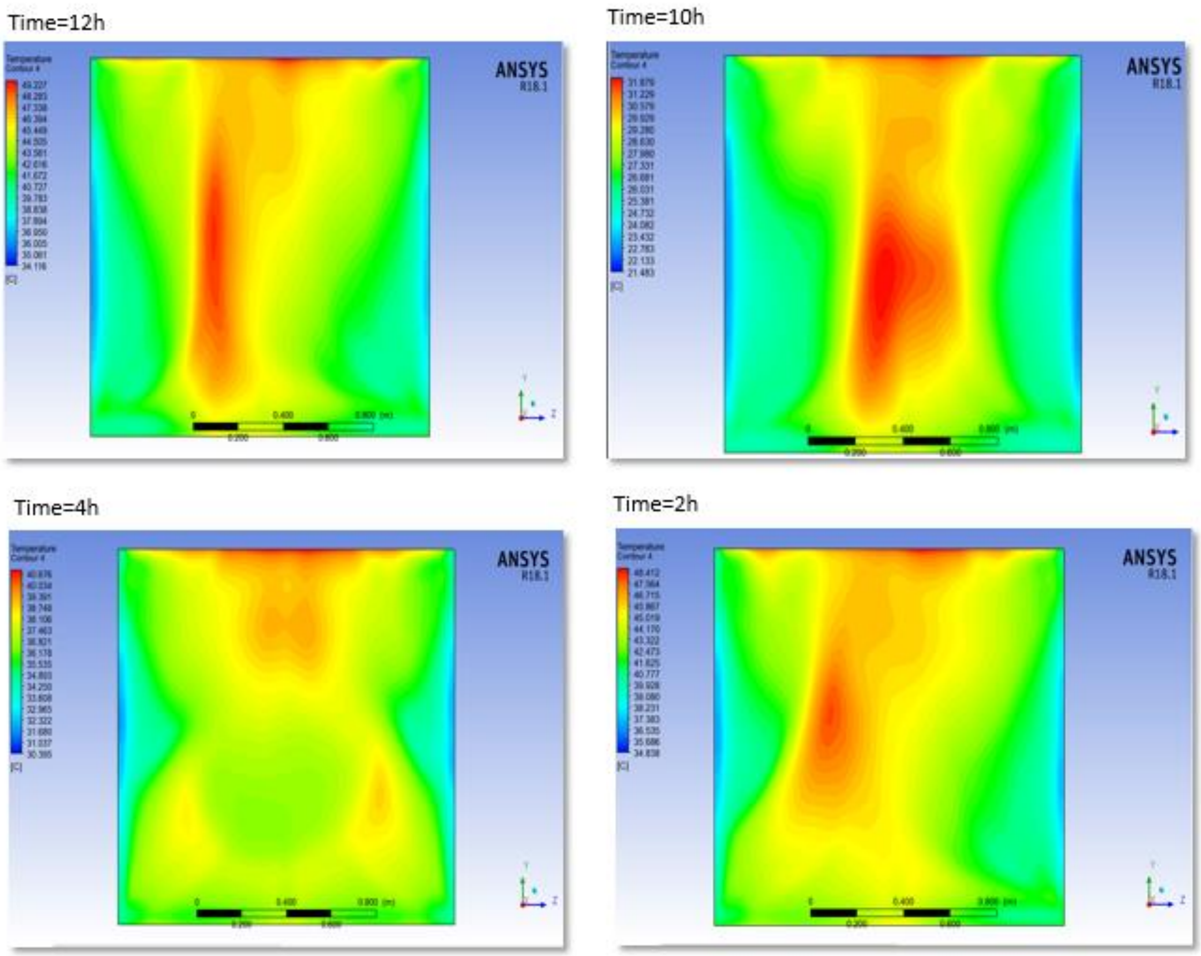


Figure 5.26 Temperature distribution contour air gap (8cm) .

Figure 5.27 Shows the contour temperature distribution on alucobond wall layer with air gap, an air gap represents temperature variation in a room wall with an 5 cm thickness. In this case, with decrease in air gap, the ability of the wall to distribute heat increases, heat distribution in wall represents periods of heat storage when the thickness of air gap is 5 cm. Reducing thickness of air gap increased rate of air heating due to reduction of the air gap in each time period. maximum air temperature, which was 20.5 °C at time, was also obtained. This increases amount of heat gained. We note that the alucobond layer is hot, which heats the cement wall because this layer has a high temperature that , acts as solar radiation on cement wall from face to face and thus increases temperature of cement wall located with coating layer.

`

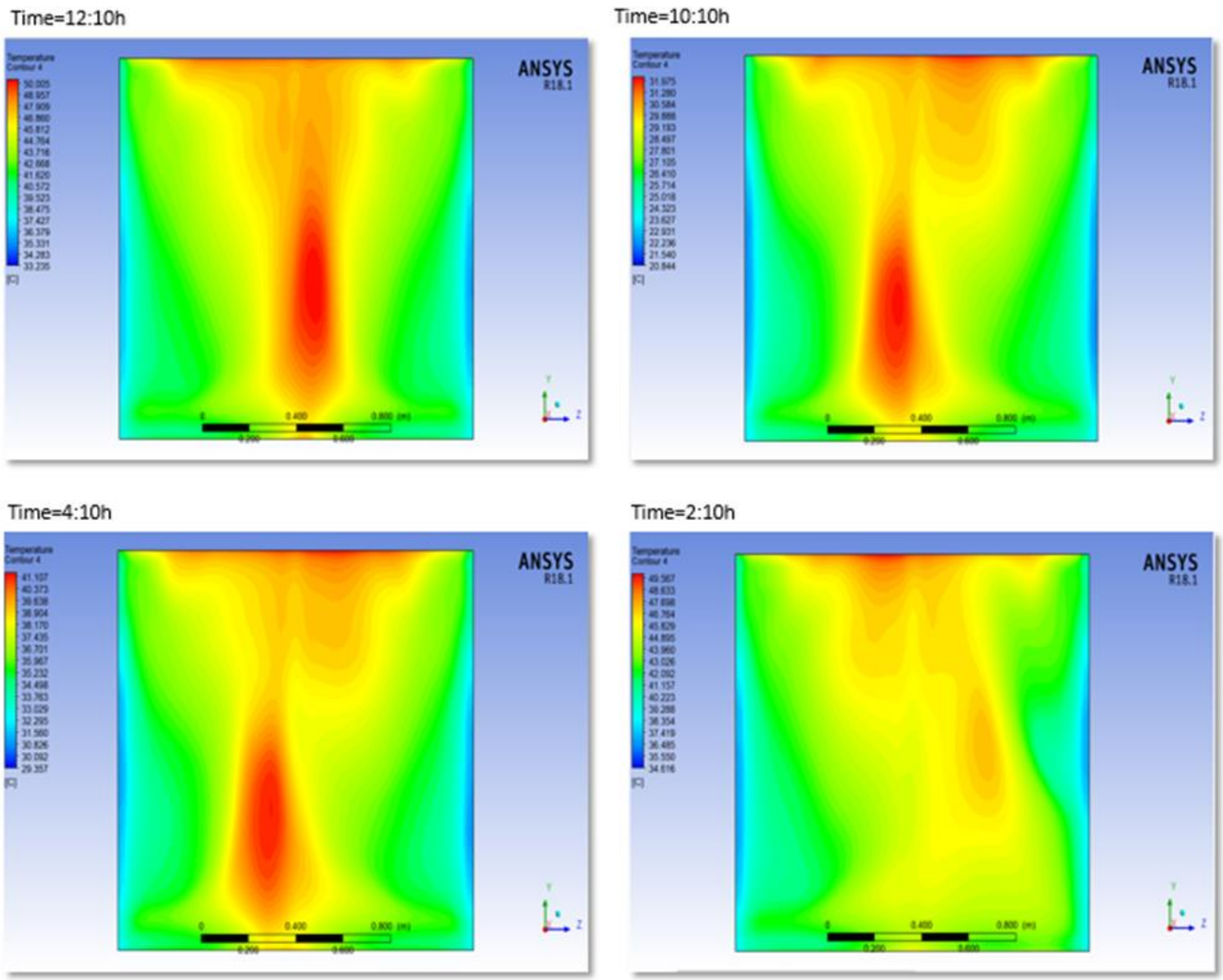


Figure 5.27 Temperature distribution contour air gap (5cm).

Figure 5.28 Shows contour temperature distribution on alucobond wall layer with air gap, an air gap represents temperature variation in room wall with an 2.5 cm thickness .Show thickness of air gap 2.5 cm, This thickness is minimal, and it will be easily heated by solar radiation causing additional load on buildings heating system. In addition , solar radiation will be stored in cement wall as reasonable energy to be used at night and vice versa In this case.

Decrease in air gap, ability of wall to distribute heat increases, The heat distribution in wall represents periods of heat storage when thickness of air gap is 2.5 cm. Reducing thickness of air gap increased rate of air heating due to reduction of air gap in each time period. maximum air temperature, which was 21.5 °C at time, was also obtained. This increases amount of heat gained. We note that alucobond layer is hot, which heats the cement wall because this layer has a high temperature that , acts as solar radiation on cement wall from face to face and thus increases temperature of cement wall located with coating layer.

Also note from air surrounding alucobond that is hot because it floats and heats up and rises to top and hot air comes out from top and acts as a solar chimney. The new study was carried out under climatic circumstances of sunny winter day. It's vital to note that the ideal thickness of air gap will not change if you choose any other day other than January for this reason. Strength of solar radiation and day outside temperature nevertheless, will have an impact on maximum quantity of heat storage.We note from presented shapes of packaging layer, that heat is concentrated in middle of packaging layer is hotter because of far distance between the exit point and the entry point.

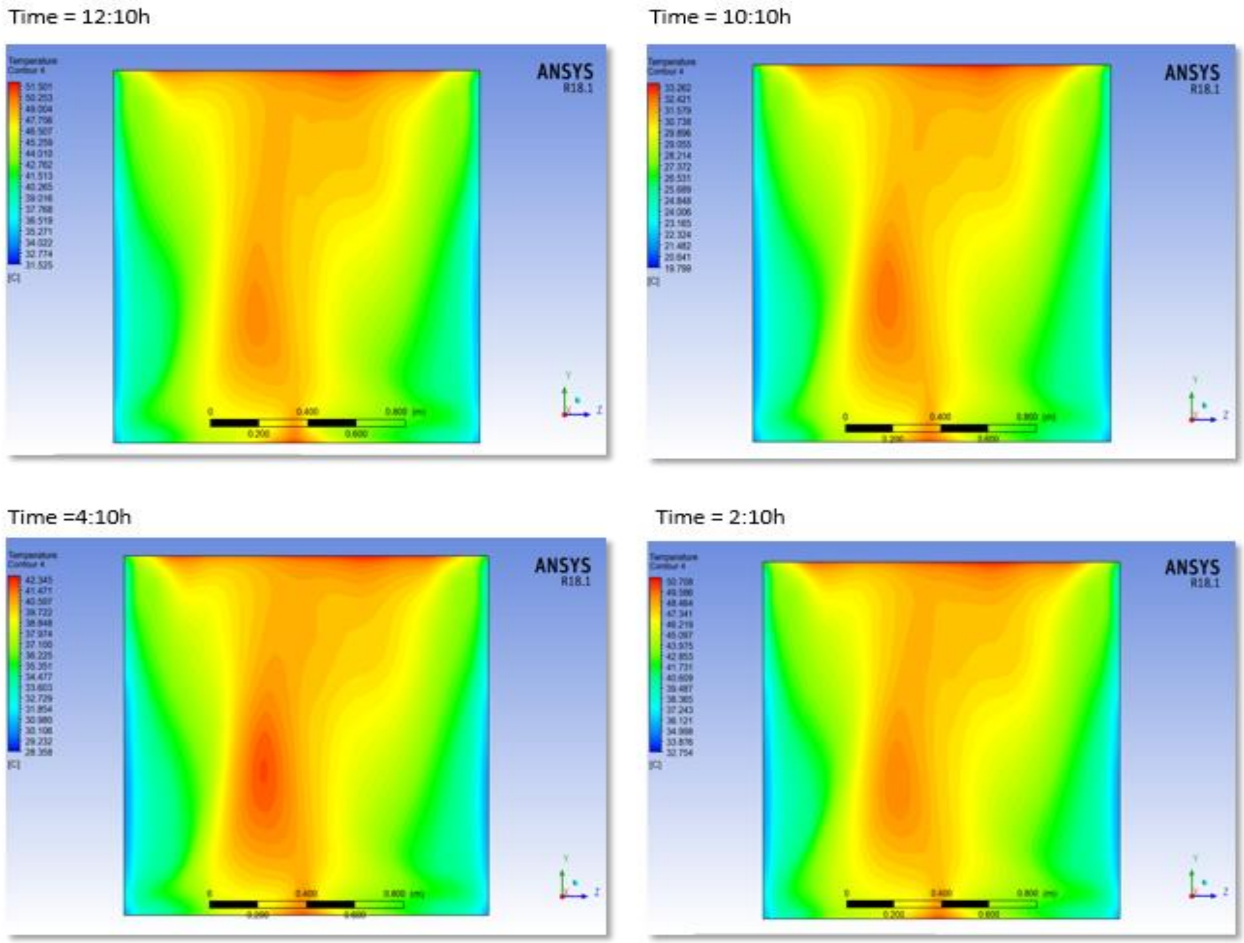


Figure 5.28 Temperature distribution contour with air gap (2.5cm).

5.4 The Comparison Results of Experimental & Numerical

1. Temperature Comparison

A comparison between experimental and theoretical results of temperature distribution of the outer and inner wall of packaging is shown in Figure 5.29, For temperature of packing wall is converged to experimental and theoretical. The average maximum temperature in experimental and theoretical (25 ℃ and 27.5 ℃), rate of difference between practical and theoretical results (9.2%) and experimental and theoretical minimum (20.5 ^{o}C & 22 ^{o}C).

`

Temperature average difference between practical and theoretical results was (6.8%).

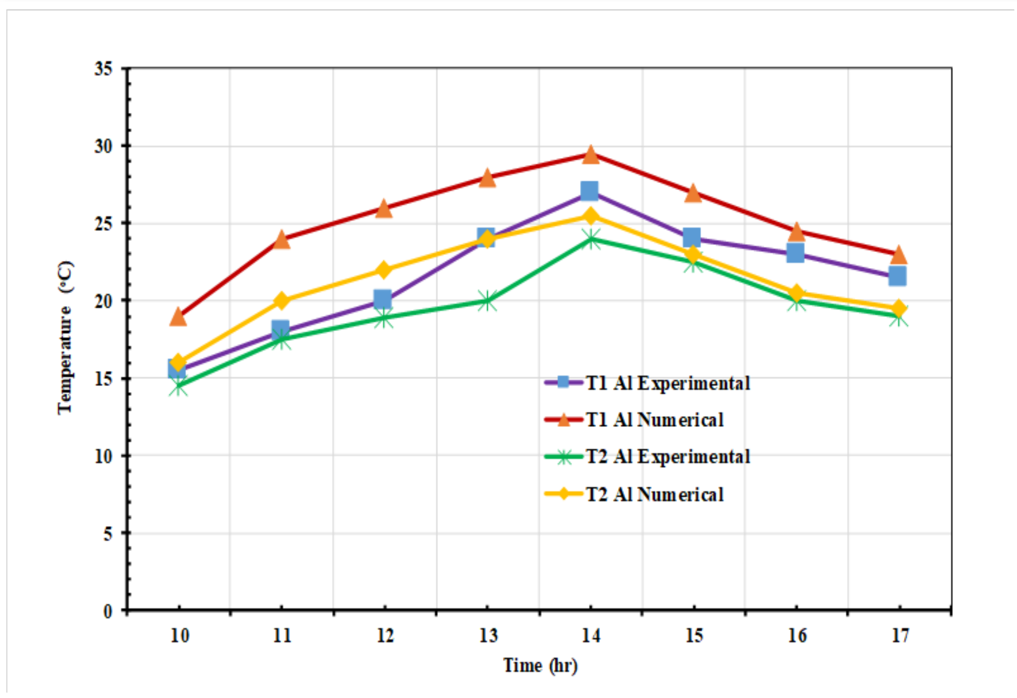


Figure 5.29 The comparison temperature of wall packaging alucobond experimental & theoretical 1/23/2022.

A comparison between experimental and theoretical results of temperature distribution of outer and inner wall of without packaging as shown in Figure 5. 30 , For temperature of without packing wall is experimental and theoretical. The average maximum temperature in experimental and theoretical (40 °C and 44 °C), rate of difference between practical and theoretical results (9.5%) ,experimental and theoretical minimum temperature (20.5 °C & 22 °C), average difference between practical and theoretical results was (9%).

`

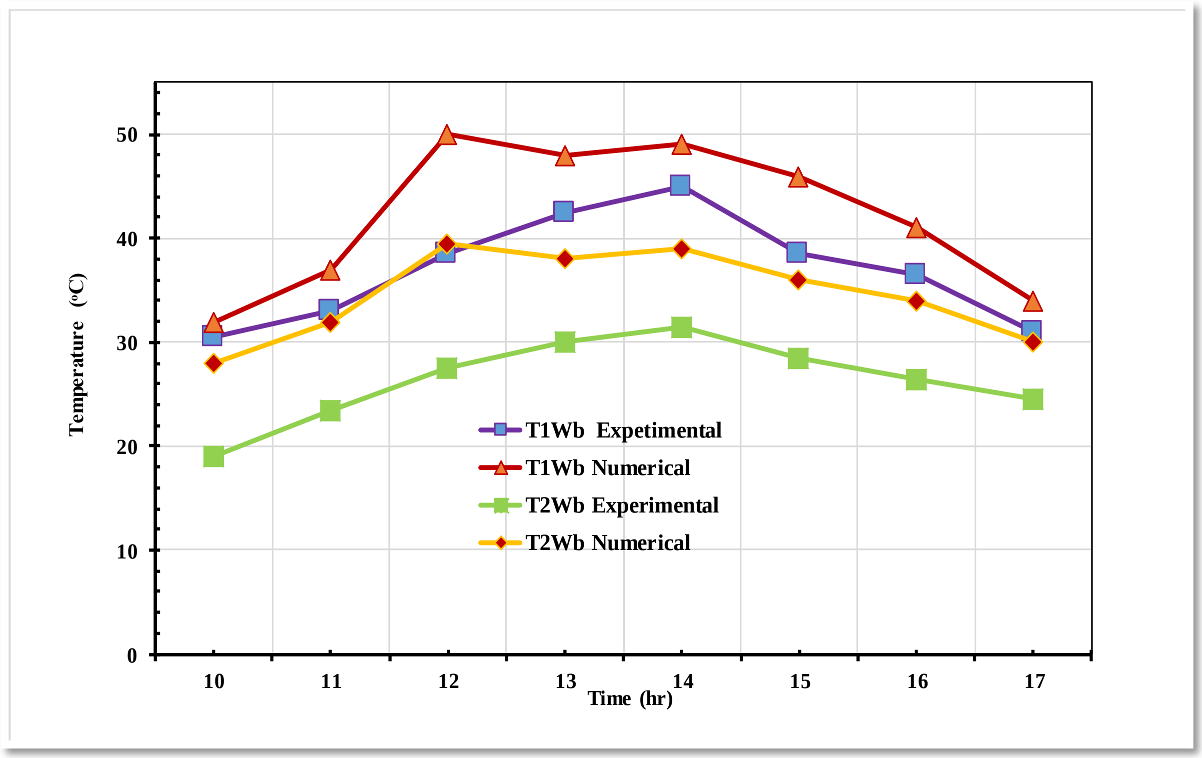


Figure 5.30 The comparison of temperature wall room without alucobond wall experimental & theoretical 1/23/2022.

2. Heating Load

The comparison between experimental and theoretical results of heating load of alucobond packaging wall is shown in figure ,5.31 as in figure alucobond heating load maximum in experiment and theoretical (18.03 w/m2 & 20.2 w/m^2) , average difference was (10%) . heating load minimum experiment and theoretical (-5.01 w/m^2 & 5.56 w/m^2) , the average difference was (9.4%) .

`

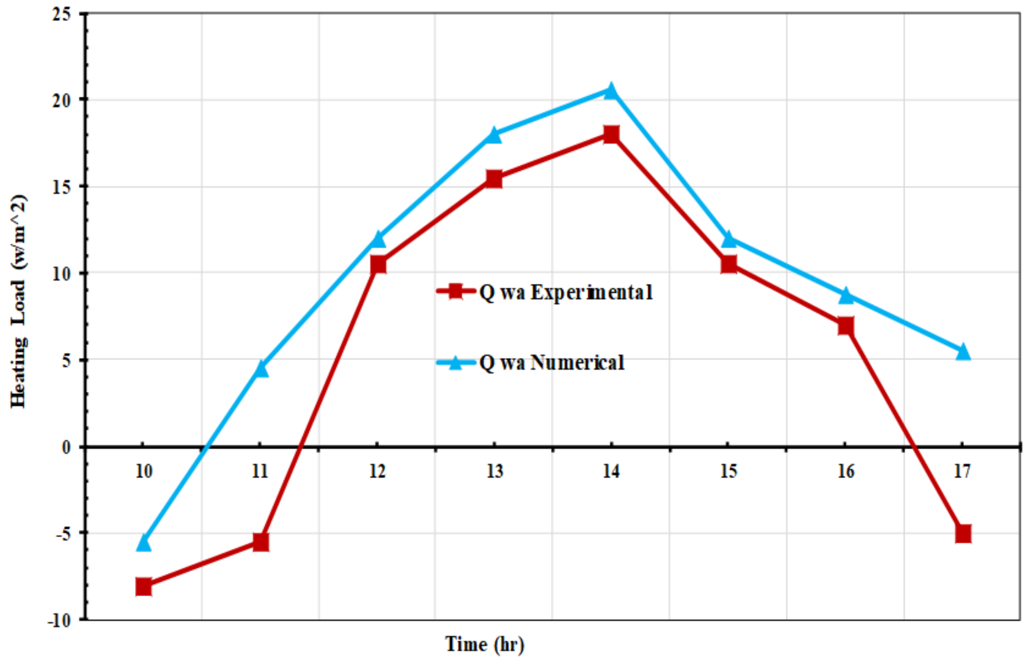


Figure 5.31 The compare heating load of wall alucobond experimental & theoretical 1/232022.

The comparing between experimental and theoretical results of heating load of wall room without alucobond packaging as shown in figure ,5. 32 shown as in figure wall room without alucobond heating load maximum in experiment and theoretical (55.5w/m2 & 62 w/m2) , the average difference was (10%) . heating load minimum experiment and theoretical (27 w/m2 & 30 w/m2) , the average difference was (9.9%) .

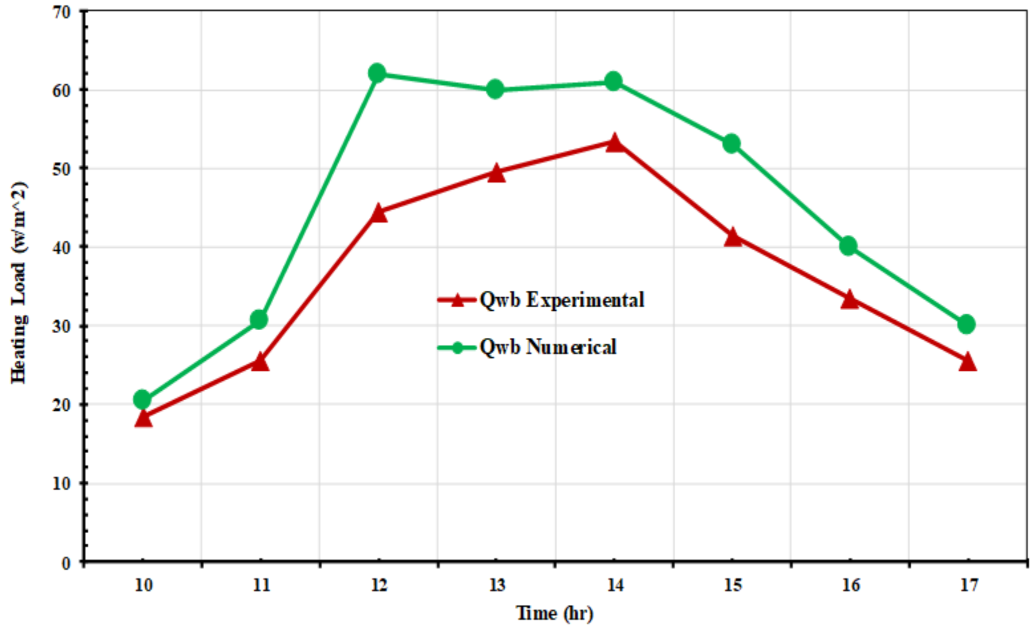


Figure 5. 32 The compare heating load of wall without alucobond experimental & theoretical 1/23/ 2022.

`

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

The aim of this research is to study effect of solar radiation falling on room wall, the temperature of insulated and non-insulated walls, temperature of the outside ambient air, as well as heat passing through the wall, with temperature of covering layer and the effect of using air gaps between the alucobond layer and the main room wall and have effects on temperatures and heat gain or heat loss. The numerical study of main room wall with the effect of different gaps (8cm, 5cm &2.5cm) included.

6.1 Conclusions

1. In this study, the outer wall was used to encapsulate the room with alucobond coating material, and this insulating layer is made of different thicknesses and most common in the market was the thickness of (4mm) and this insulating layer is characterized by its good thermal insulation due to the low thermal conductivity of the used packing material.

2. In the practical study, the air gaps (8, 5and 2.5 cm) were used. Energy save, respectively, (92%, 88% and 73%), it was found from the practical test that the best energy saving has (air gap of 8 cm 92%) because the heat is transmitted from the outside to the inside and the space operates as heating, so heat in the winter season is always outside and not inside.

3. The study of Computation Fluid Dynamics ability has showed to predict the normal conductivity and load thermal in main room wall system, which consists of bricks and two layers of cement. The room dimensions were (1.56m x 1.5m x 1.5m), simulation was used using ANSYS – FLUENT program.

4. The recent study was conducted using climatic conditions for a sunny day in the winter month January, 23/1/2022/. It is noticed that choosing any other day to study this test will not affect the same results.

5. According to the presented results, it is clear that the thickness of air gap of (8 cm) on the heat distribution of room wall and movement of air is better than other studied gaps. In this case the decreases heat distribution in room wall the .

6. Increase in air gap increases the amount of air bound in gap, which reduces the heat gained. Reducing air gap increases the temperature distribution through the room wall, and air speed increases with the decrease in air gap.

7. The air that surrounds the alucobond layer is hot because it floats and heats up and rises to the top and the hot air comes out from the top and works as a solar chimney.

6.2 The Recommendations

- The use of insulating materials with the used of packaging materials .
- The use of forced convection heat transfer the fluid .
- Study the effect of using PCM .
- The work takes place in the winter and summer to know the effect of the solar radiation falling on the wall of room.
- Study the effect of using exterior colors for room walls on thermal performance, to know their effect on heating and cooling loads in winter and summer.

`

REFERENCES

`

Reference

[1] Abdul Karim, M.A.B. and A.M.B. Razali, 2012. Forecasting global solar radiation using statistical method. Sains Malaysian, 31: 149-158.

[2] M. Maasoumy, B. Moridian, M. Razmara, M. Shahbakhti. Online simultenous state estimation and parameter adaptation for building predictive control. In Proceedings of the ASME Dynamic Systems and Control Conference. pp. V002T23A006, Palo Alto, California, USA, 21-23 October 2013.

[3] Zhang Jingquan. Research Status Quo and Developing Trend of External Wall Thermal Insulating Technology. Technology Information, 2016,(5):329.

[4] ASHRAE 1974. ‘‘Thermal comfort conditions for human occupancy,’’ ASHRAE Standard55-1974, American Society of Heating, Refrigerating and Air-Conditioning Engineers, New York.

[5] A. Synnefa, M. Santamouris, and I. Livada, “A study of the thermal performance of reflective coatings for the urban environment,” Sol. Energy, vol. 80, no. 8, pp. 968–981, 2016.

[6] Bellia, L., Marino, C., Minichiello, F., & Pedace, A. (2014). An overview on solar shading systems for buildings. Energy Procedia, 62, 309-317. Collage Sc. J., 32–50.

[7] R Berry, S J Livesley, and L Aye 2017. Tree canopy shade impacts on solar irradiance received by building walls and their surface temperature J Building and Environment. 69 91-100.

[8] ANG, B. W. – WANG, H. – MA, X. 2017. Climatic in□uence of electricity consumption: The case of Singapore and Hong Kong. In Science Direct, vol. 127, pp. 534–543.

[9] CVIKLOVIČ, V. – OLEJÁR, M. – HRUBÝ, D. – LUKÁČ, O. – PALKOVÁ, Z. – PAULOVIČ, S. – PÁNIK, V. – ADAMOVSKÝ, F. 2017. Method and device for electric power supply of a single-phase appliance during a failure of one or multiple phases. Geneva: WIPO, 1 p. Available at: < https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2017051277 >.

`

[10] Ali H. T., Fouad A. S. and Wathiq A. A.," Experimental and Theoretical Study to Minimize the Cooling Load by Using a New Alternatives in a Space located in Baghdad City", Journal of Engineering and Development, Vol. 13, No. 3, September (2019).

[11] S.A. Al-Sanea, M.F. Zedan, Effect of insulation location on thermal performance of building walls under steady periodic conditions, Int. J. Ambient. Energy 22 (2016) 59–72.

[12] Fatima M. E.," Thermal comfort Investigation of multi-storey residential buildings in Mediterranean climate With reference to Darnah, Libya", The University of Nottingham Department of Architecture and Built Environment,(2015).

[13] M. Ibrahim, N. Ghaddar, K. Ghali, Optimal location and thickness of insulation layers for minimizing building energy consumption, J. Build. Perform. Simul. 5 (6) (2016) 384–398.

[14] Nazar F. A., Hassan K. A. and Asslan M. M. K.," Reduced the Cooling Load and Improved Insulation Effect on Iraqi Buildings Using the Geothermal Energy Storage Phenomenon", Dept. of Mechanical Eng., University of Technology, Vol.25, No.9, (2017).

[15] Sajad M. Aboud "Reduction of Heat Transfer through Walls in Buildings by using Insulation" University of Wasit International Journal of Computer Applications (0975 – 8887) Volume 141 – No.4, May 2016.

[16] David. Y.K" Study Of The Influence Of Roof Insulation Involving Local Materials On Cooling Loads Of Houses Built Of Clay And Straw. 03 BP 7021 Ouagadougou 03, Burkina Faso (ousmane.coulibaly@univ-ouaga.bf; togyen@univouaga. bf; jean.koulidiati@univ-ouaga.bf) in (2018).

[17]] L.T. Yuan, Y.M. Kang, S.H. Wang, K. Zhong, Effects of thermal insulation characteristics on energy consumption of buildings with intermittently operated air-conditioning systems under real time varying climate conditions, Energy Build. 155 (2017) 559–570.

`

[18] Maytham. I. Q.," Reduction Of Heat Transfer Through Walls In Building By Using Local Natural Insulation In Iraq", The Iraqi Journal For Mechanical And Material Engineering, Vol. 13, No. 3, (2016).

[19] A. Azarnejad, T. U. Wien, B. M. View, and A. Azarnejad, “Impact of Building Façades ’ Color on Building and Urban Design,” no. June, 2017.

[20] Atiff A. H.," The Environmental Effect Reduction On Internal Space Temperature By Internal Walls Covering", journal of kerbala university, Vol. 10, No. 2, (2016).

[21] Hayder M. B.," Experimental Study Of A Typical Iraqi Wall Thermal Performance With Q-Bond Insulation In Winter Conditions", Al-Qadisiya Journal For Engineering Sciences, Vol. 5, No. 1, (2012).

[22] Ali. M. B.," Experimental Study Of A Typical Iraqi Wall Thermal Performance With Q-Bond Insulation In Winter Conditions", Al-Qadisiya Journal For Engineering Sciences, Vol. 5, No. 1, (2017).

[23]- Nadia S. I. and Duaa M. D.," Recycling plants waste for plastic to work packaging boards business walls and ceilings insulated to moisture and heat", Engineering and Development Journal, Vol. 14, No. 2 , June(2010).

[24] Ayad k. K., Nasr H. F.l, Ali A. W.," Comparison of thermal behavior of natural and industrial packaging materials to the walls on the cooling load in Baghdad", Journal of Babylon University, Engineering Sciences,No.(4),Vol.(21), (2013).

[25] Vaughn B.,” The Building Environment: Active and Passive Control Systems”, Wiley; 3 edition, 2006.

[26] Peter D.,” Climate: Design: Design and Planning for the Age of Climate Change”, ORO editions, (2009).

`

[27] Nora R.," Adoption of the principle of equal thermal energies General ideal geometric composition prediction for the cover of the building", Master thesis, Department of architecture, University of technology, Iraq, (1996).

[28] C. Gallo, Marco Sala & A. A. M. Sayigh," Architecture- comfort and Energy", Pergamon Press Inc, (1998).

[29] Gamal A. W. S.," Energy And Environmental Performance Of A Complementary Design For The Cover Of The Building",Master Thesis, Department of Architecture, University of Technology, Iraq, (2007).

`

APPENDIX A
CALIBRATION

`

APPENDIX A

A – Calibration

Method Calibration mercury thermometers and thermocouples were placed in beaker filled with ice at temperature of (0°C) with a cup of boiling water at boiling temperature of 100 °C and room temperature at a temperature of (25°C) , with data logger that was calibrated using 10 Thermocouples , The thermometer temperature is recorded directly. Almost different temperatures Between thermometers and thermocouples, the difference was very little, as we saw in the curves below are between thermometer and thermocouple temperatures. The data logger was used to measure temperature of external and internal walls and the insulation wall of the test rooms , in addition to temperature of outside ambient air. These devices are characterized by appropriate measurement accuracy and easy to used .

A – 1 Calibration Of Thermocouples

Thermocouple-type temperature by connecting them to multimeter or data recorder, sensors are frequently employed as temperature sensors. It is more frequently employed in testing because the (2M) K type thermocouple had the best accuracy among the many thermocouple types utilized in studies and was best suited for temperature range. Considering that tools are simple to use and have adequate measuring precision, By calibrating the apparatus under standardized settings or by making comparisons with other relevant measurement instruments, the accuracy of measurements can be verified. The right measurement tools must be matched with calibrated gauges. Thermocouples are type of temperature sensor utilized in numerous engineering studies. Ten type K (2M) thermocouples were used in experiment. location of all thermocouples The relationship between thermocouple results and the standard mercury thermometer (Hg) is shown in a table (A.1) and figure (A.1), and all the thermocouples connected to the data logger were calibrated collectively.

`

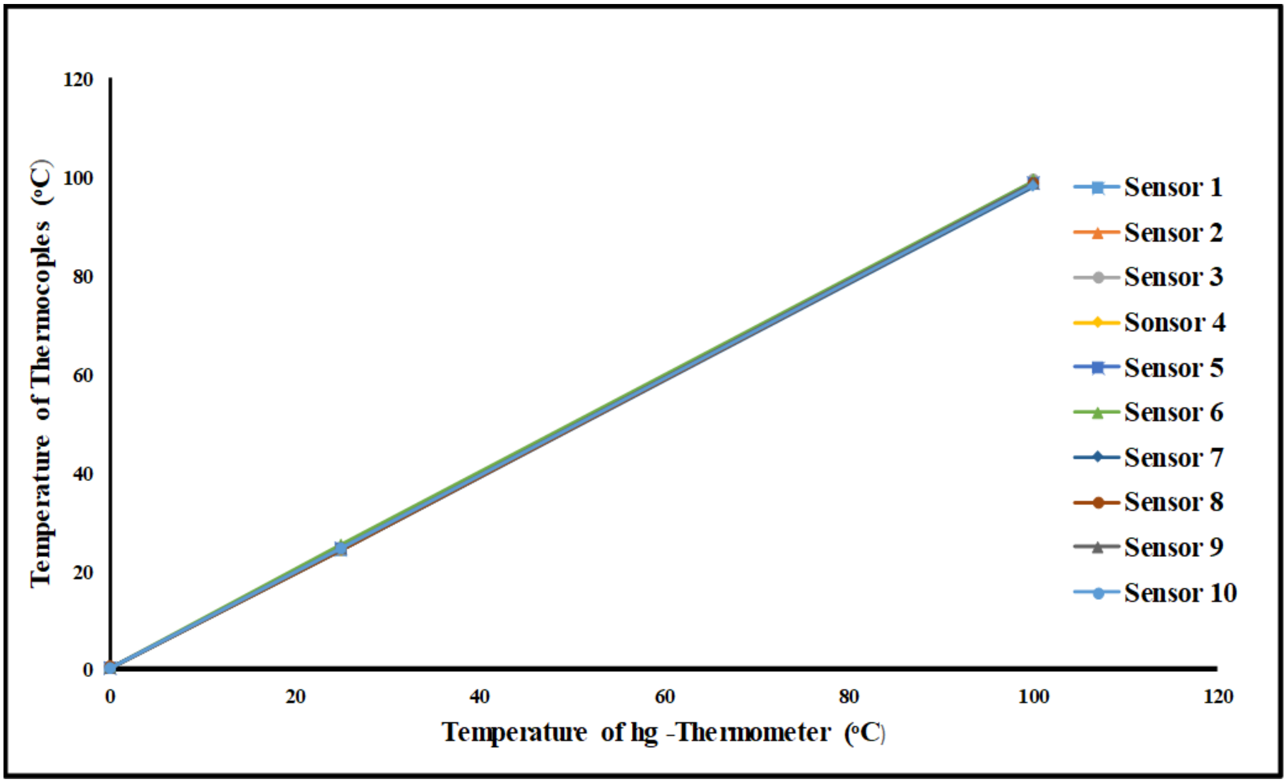


Figure A.1 . Calibration of Thermocouples.

Table - A.1- Calibration thermocouples of type K (2M) provided from the test Experimental with (Hg) thermometer.

Device Type	Freezing Temperature (0 °C)	Temperature Room (25 °C)	Boiling Temperature (100 °C)
Thermometer (Hg)	0	24.6	99.4
Sensor 1	0.18	24.1	98.72
Sensor 2	0.12	24.3	98.92
Sensor 3	0.15	24.14	99.2
Sensor 4	0.2	24.12	98.62
Sensor 5	0.15	24.32	98.54

`

Sensor 6	**0.20**	**25.17**	**99.21**
Sensor 7	**0.25**	**24.28**	**98.13**
Sensor 8	**0.21**	**24.35**	**98.42**
Sensor 9	**0.18**	**24.51**	**98.57**
Sensor 10	**0.13**	**24.4**	**98.28**

`

APPENDIX B
DATA
EXPERIMENTAL
WORK

`

APPENDIX B

Table – B.1 – Data Experimental work of Temperature walls and walls package Alucobond with Temperature outside ambient air for days (2022/1/23,24 & 25) .

Time (hr)	TFW1 OUT	TFW2 IN	TFW3 OUT	TFW4 IN	TR1	TW1 OUT	TW2 IN	TR2	TA OUT Ambient
10:10	26	23	11	7	25	25	14	25	9
11:10	30	28	13	9	25	35	20	25	12
12:10	32	30	15	10	25	39	24	25	13
13:10	34	32	17	12.5	25	46	30	25	16
14:10	35	33	21	14	25	50	32	25	16
15:10	28	26	20	17	25	47	33	25	16
16:10	25	24	20	18	25	45	32	25	16
17:10	20	21	19	18	25	31	27	25	14

Table – B.2 – Data this information is taken from Meteorology of Solar Energy and Speed wind for days (2022/1/23,24 & 25) .

Time (hr)	Solar Energy (w/m^2)	Speed Wind (km/h)
10:10	6.44	9.5
11:10	7.46	11
12:10	9.39	9.5
13:10	8.77	7.6
14:10	9.05	8.5
15:10	8.5	10
16:10	6.2	12
17:10	3.77	13

`

Table – B.3 – Data of Experimental work of Temperature walls and walls package Alucobond with Temperature outside ambient air for days (2022/2/6&8) .

Time (hr)	TFW1 OUT	TFW2 IN	TFW3 OUT	TFW4 IN	TR1	TW1 OUT	TW2 IN	TR2	TA OUT Ambient
10:10	30	28	15	12	25	27	17	25	13
11:10	33	31	17	14	25	35	23.5	25	16
12:10	36.5	34	19	16	25	43.5	27.5	25	17.5
13:10	37.5	36	20.5	17	25	47.5	31	25	19.5
14:10	39	36	22	18.5	25	55	38	25	20
15:10	36	35	21.5	18.4	25	54.3	38.5	25	19
16:10	30	28	22.5	20.5	25	55	41.5	25	19
17:10	18	19	21	22	25	36	35.5	25	18

Table – B.4 – Data this information is taken from Meteorology of Solar Energy and Speed wind for days (2022/2/6 & 8) .

Time (hr)	Solar Energy (w/m^2)	Speed Wind (km/h)
10:10	7.7	4.5
11:10	10.5	4
12:10	11.156	3.5
13:10	11.154	2
14:10	11.116	6.5
15:10	9.94	12
16:10	8.095	13
17:10	5.155	16

`

Table – B.5 – Data of Experimental work of Temperature walls and walls Package Alucobond with Temperature outside ambient air for days (2022/2/27&28).

Time (hr)	TFW1 OUT	TFW2 IN	TFW3 OUT	TFW4 IN	TR1	TW1 OUT	TW2 IN	TR2	TA OUT Ambient
10:10	35	33	21	17.5	25	35.5	26	25	19.5
11:10	39.5	37	23	19	25	44	30.5	25	21
12:10	42.5	40	25	21	25	49	33.5	25	22.5
13:10	45	42.5	26.5	22	25	55	37.5	25	23.5
14:10	46.5	44	27.5	23	25	56.5	39	25	23.5
15:10	42.5	41.5	26	22	25	55	37	25	22.5
16:10	33.5	34.5	28	25.4	25	54	42.5	25	21.5
17:10	26	27	29	27.5	25	47	38.5	25	20

Table – B.6 – Data this information is taken from Meteorology of Solar Energy and Speed wind for days (2022/2/27 & 28).

Time (hr)	Solar Energy (w/m^2)	Speed Wind (km/h)
10:10	7.93	2
11:10	11.77	3
12:10	13.455	2.5
13:10	13.18	3.5
14:10	13.125	2
15:10	11.765	7.5
16:10	9.496	9.5
17:10	7.16	10

APPENDIX C
PAPERS PUBLICATION FROM THESIS

`

APPENDIX C

1.A Review Paper : Study Effect Heat Transfer Convection Natural In Vertical Channel.

ISSN: 0974-5823 Vol. 7 No. 8 August, 2022

International Journal of Mechanical Engineering

A Review Paper :Study Effect Heat Transfer Convection Natural In Vertical Channel

Walla A .Naje[1] And Zaid M .Hasan[2]

[1]Mechanical power Department / Engineering College / Najaf University /Najaf , Iraq.

Abstract

The goal of the research is to increase thermal efficiency of the natural heat flow, which is a result of the high temperature differential in closed vertical channel, by optimizing the distance between the channels through a number of trials. The study looked at data on heat transmission by natural convection that was obtained in various hot plate references. Additionally, the vertical face up and the investigation of the heat source positioned in the vertical channel were covered. Heat exchangers, fuel elements, nuclear reactors, heat dissipation in electronic circuits and cooling towers are only a few examples of devices that use convective heat flow transfer with the inner body in a vertical channel. In several studies on the significance of heat transport, much computational, analytical, and experimental work has been done.

Keywords : Natural convection (free convection), vertical channel, convection heat Transfer, Induced Flow, aspect ratio.

2.1 INTRODUCTION

Many engineering applications such as cooling of electronic equipment, electrical transformers, chimneys, furnaces, the cooling of solar collectors, and geophysical fluxes, include natural convection heating. The energy exchange that occurs as a result of heat flowing through various liquids used in thermal energy conversion devices determines how well they operate. Usually, volumetric heat creation or heat transfer rate from heated surface is the cause the heating. Due to the link of fluid flow and heat transfer the process of heat transfer through free convection is a separate phenomenon of interest. Between vertical walls, it has received substantial research due to its significance in numerous technical applications as well as its applications to numerous naturally occurring systems. To reduce heat, air conditioning is frequently employed. Application simplicity and accessibility are the primary benefits of air cooling. The simplest way to cool is to use natural convection to move air. Due to its low noise and maintenance-free benefits, natural convection to cool electronics equipment continues to play a significant role in thermal management [1]. By transferring effective heat from the exterior of a copper vessel used in a pressurized water reactor to the upward flow of induced air caused by buoyancy through the space between the vessel and the external concrete wall, natural heat transfer between vertical walls is achieved. This is due to the way buoyancy affects the turbulence in boundary layer, which results in flow that develops its distinctive characteristics at the Reynolds number. By boosting convection or reducing the heat flow rate, the heat transfer weakens gradually as the buoyancy effect gets stronger. In many technological applications, including cooling electronics equipment and solar collectors, natural convection in vertical channels is crucial[2]. On a common scale for extended periods, emphasis is given on the transport phenomena and the significance of heat flow produced by buoyancy in electron shells. The location of energy sources, radiation, and the 3D effect are only a few of the numerous additional effects that are significant. In the previous years, a significant. Many researchers have now integrated some of these effects to produce extremely useful data for thermal analysis and system design [3].

2.2 Literature Review

In all nations, buildings are regarded as consuming the most heat. There is a more complicated link between the energy needed for heating in winter residential structures in places with climatic parameters

`

2. REDUCTION OF TEMPERATURE THROUGH WALLS IN ROOM BY USING PACK AGING MATERIAL (ALUCOBOND) .

JOURNAL OF HARBIN INSTITUTE OF TECHNOLOGY
ISSN: 0367-6234 Vol. 54 Iss. 9 2022

REDUCTION OF TEMPERATURE THROUGH WALLS IN ROOM BY USING PACKAGING MATERIAL (ALUCOBOND)

Walla A. Naje*[1], Zaid M. Hasan[2] & Mohamed A. Al-Fahham[3]
[*1,2&3]Mechanical power Department / Engineering College / Najaf University /Najaf, Iraq

ABSTRACT

The present work shows how insulation can be used for walls of new buildings. To reduce the amount of electricity used. The experiment was carried out in the winter at the Technical University of Engineering (Najaf city, latitude 32.5 north), Iraq. Using a test model of two similar sandwich panels. Two rooms (1.65 m long, 1.5 m wide and 1.5 m high) facing south. The first wall was built of bricks (12cm) thick and covered with a layer of cement (Ficus) (1cm) thick. As for the second wall, the same as the first, but the second wall of the room is covered with alucobond material in front of the built wall and contains air gaps that are between the wall and the covering layer. Due to the high absorbency of cement with low thermal conductivity of the packing materials used, there was a large discrepancy between the internal and external temperature of the non-covered wall and the insulated wall. We note that the use of alucobond panels in general does not reduce the value of the heat transfer coefficient as it remains above international standards, however, the presence of these panels alucobond reduces the heat load.

Basic terms: area (m^2), Q Heat load rate (w/m^2), time (sec., °C), thermal resistance ($m^2.°C/W$), thermal conductivity (W/m.°C) & convective heat transfer coefficient ($w/m^2.c$).

Keywords: shading wall (Alucobond), cement (ficus) , brick , Insulation , solar energy and heating load.

DOI:10. 11720/JHIT. 54092022. 14

1. INTRODUCTION

Iraq is situated in a subtropical area with a desert environment, which is hot and dry. The sun stays out for over seven months (more than 12 hours per day), and the temperature in the shade rises above (45 degrees Celsius). As a result, the exterior walls are exposed to heat waves, whose duration and intensity are inversely correlated. [1] weather conditions and the sun appropriate for heat. In the summer, horizontal surfaces exposed to solar radiation of more than 780 W/m2 have uncomfortable inside temperatures. If insulation materials like shading walls are employed, the amount of cooling and heating equipment needed is significantly decreased, saving electrical energy. [2] Compared to lighting and other uses, cooling, heating, comfort, and weather loads account for the majority of energy consumption in Iraq.

The goal of the current study is to demonstrate how using building insulation affects the heating and cooling demand. Due to the extreme heat in Iraq, where the average temperature is over 50 degrees Celsius, external insulating walls play a significant role in how much sunlight is reflected or absorbed, which in turn affects how much heat is gained through the wall. In the winter of January and February 2022, work was completed. Adding wall shading reduces the temperature decreasing the quantity of heat transmitted through them by lowering the surface exposed to direct sunshine. Because it is possible to lower the building's temperature and hence lower energy consumption for heating and cooling, this function offers a natural answer to lowering temperatures in hotter places [3].

High temperatures, direct solar radiation, and other challenging climatic conditions affect hot and dry places, where facades serve as the main barrier against those conditions [4]. One of the most crucial design tactics is the use of shading techniques. It aims to block a significant portion of the sun's direct light. to lower the temperature behind roofs, incident solar radiation, and surface temperatures outdoors. It also seeks to lessen the heat that solar radiation causes the walls to absorb, which will require less energy for cooling. Provide ideas to building shade walls using bricks and assess these possibilities using modeling tools to reduce surface temperatures exposed to direct sunlight as effectively as possible. Consequently, less heat is transported through the walls [5]. To improve the aesthetic appeal at various building heights, aluminum bond can be put on the exterior of structures. (ACP) is the best material for building façade maintenance and remodeling since it is flexible, lightweight, easy to maintain, and doesn't add to the dead load of structures. It can also be fitted in any form because it is a flexible material [6].

`

3. Simulation By Using ANSYS-FLUENT of Wall Room With Effect Air Gaps Between Walls .

SOLID STATE PHENOMENA

Academic Paper Acceptance Letter

Date: 15-10-2022.

Title: Simulation By Using ANSYS – FLUENT Of Wall Room With Effect Air Gaps Between Walls.

Dear Authors: Walla A .Naje[1], Zaid M .Hasan[2] and Mohamed A. Al-fahham[3].

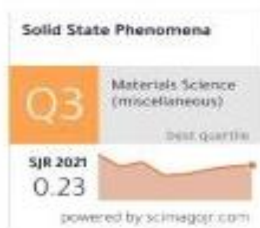
[1,2,3]Al-Furat Al-Awsat Technical University ,Technical Engineering College / Najaf Mechanical engineering techniques of power, Iraq.

***Corresponding Author:** walaa.ali@student.atu.edu.iq.

It's our great pleasure to inform you that your above-mentioned manuscript has been reviewed and accepted for publication in special issue Journal of **Solid State Phenomena** with **ISSN 1662-9779**. Your article will be published in forthcoming special Issue as known: **(Applied Engineering Materials: Development, Characterization, Simulations)**. This letter of acceptance be considered as the official acceptance of your manuscript with no further amendments required. Use below link to find article formatting instruction to format article according to journal format.

Author Instruction Link: https://www.scientific.net/special-issue/5358/applied-engineering-materials-development-characterization-simulations

Kind regards



Guest Editors
Dr. Amit Pandey
Solid State Phenomena
Publisher: Scientific.net
ISSN 1662-9779
https://www.scientific.net/SSP/Details
Special Issue:- Applied Engineering Materials: Development, Characterization, Simulations
https://www.scientific.net/special-issue/5358/applied-engineering-materials-development-characterization-simulations

Scientific.Net
Publisher in Materials Science & Engineering

`

الملخص

تم إجراء دراسة تجريبية ورقمية لمواد التغليف لجدار الغرفة باستخدام عدة فجوات مختلفة ، الهدف من هذا العمل .الكوبوند ومواقع هذه الفجوات بين الجدار الرئيسي للغرفة وتغطية الجدار هو تقليل الحمل الحراري للغرفة الجدار في العمل الحالي. تم تنفيذ العمل الحالي بالكلية التقنية للهندسة (مدينة النجف الاشرف) لنموذج الغرفة الاولى التي تم بناؤها لتكون على اتصال مباشر مع الاشعاع الشمسي ، والغرفة الثانية تحتوي على عازل حراري في الشتاء باتجاه الجدار الجنوبي في (2022) كانون الثاني وشباط. أوضحت الدراسة تأثير استخدام العزل الحراري على الجدار في تقليل كسب وفقد الحرارة من خلال هذا الجدار. نفذت التجربة في فصل الشتاء في الجامعة التقنية للهندسة (مدينة النجف ، خط الطول 44 شرق و خط عرض 32.5 شمال) ، العراق. استخدام نموذج اختبار لوحين متشابهين. غرفتان (بطول 1.65 متر وعرض 1.5 متر وارتفاع 1.5 متر) تواجه الجنوب. أول جدار مبني من الطوب بسمك 12 سم ومغطى بطبقة من الإسمنت بسماكة 1 سم. أما بالنسبة للجدار الثاني ، فهو كالجدار الأول ولكن الجدار الثاني للغرفة مغطى بمادة الكوبوند أمام الجدار المبني ويحتوي على فجوات هوائية بين الجدار وطبقة التغطية. بسبب الامتصاص العالي للأسمنت مع الموصلية الحرارية المنخفضة لمواد التغليف المستخدمة ، كان هناك تباين كبير بين درجة الحرارة الداخلية والخارجية للجدار غير المغطى والجدار المعزول. يقلل هذا الجدار من الحرارة داخل الغرفة بسبب التوصيل الحراري المنخفض للطبقة العازلة ، وتتمثل فائدة هذا التأثير في تقليل كمية استهلاك الطاقة لغرض التبريد والتدفئة في الشتاء والصيف. ، وقد تم صنع الكوبوند في هذه الدراسة تم استخدام الجدار الخارجي لتغليف الغرفة بمادة طلاء هذه الطبقة العازلة بسماكات مختلفة وأكثرها شيوعًا في السوق كان سمكها (4 مم). تتميز هذه الطبقة العازلة بعزلها الحراري الجيد بسبب التوصيل الحراري المنخفض لمواد التغليف المستخدمة. في الدراسة التجريبية ، تم استخدام فجوات هوائية (8,5 و 2.5 سم) ، وكلما كانت أكثر سمكًا ، زادت الفوائد التي ستحصل عليها. في هذه الدراسة ، فإن إمكانية الحصول على فجوة أفضل هي. تم اختيار أفضل فجوة هوائية تقلل من درجات الحرارة ، 8 سم ، لأن طبقة الألوكوبوند من مواصفاتها مصنوعة من مادة معدنية ، كلما كان الهواء القريب من الجدار ساخنًا ، أي أن هناك انتقالًا للحرارة. تظهر نتائج العمل التجريبي أنه عند استخدام مواد التعبئة والتغليف مع وجود فجوات هوائية خارجية سيتم توفير الطاقة ، تم توفير الطاقة على التوالي (92٪ ، 88٪ ، 73٪) ، ومن الاختبار العملي وجد أن أفضل توفير للطاقة (فجوة هواء 8 سم 92 ٪) لأن الحرارة تنتقل من الخارج إلى الداخل ويعمل الفضاء كدفئة ، فإن الحرارة في الشتاء تكون دائمًا بالخارج وليس بالداخل.

`

تم إجراء دراسة حديثة لتقييم سماكة فجوة ANSYS - FLUENT. تم استخدام برامج المحاكاة الهواء المثلى لنظام جدار الغرفة مع غلاف من الألوكوبوند. أجريت الدراسة الحديثة باستخدام الظروف المناخية ليوم مشمس في شهر الشتاء يناير / كانون الثاني 23/1 2022. وبحسب النتائج المعروضة يتضح أن سماكة فجوة الهواء (8 سم) على التوزيع الحراري لجدار الغرفة وحركة الهواء. أفضل من الفجوات المدروسة الأخرى ، وفي هذه الحالة ينخفض توزيع الحرارة في جدار الغرفة. تؤدي زيادة فجوة الهواء إلى زيادة كمية الهواء المرتبطة بالفجوة ، مما يقلل من الحرارة المكتسبة. أظهرت النتائج أن التوزيع الحراري لجدار غرفة الاختبار للشهرين الأول والثاني كان له أعلى قيمة عند الساعة 2 ظهراً ، حيث وصلت درجات الحرارة في تلك الساعة إلى 56 درجة مئوية للجدار بدون ألوكوبوند ، بينما وصل الجدار المحتوي على الألوكوبوند إلى 27 تم عمل ووجدت أن ارتفاع النتائج للحالات العملية والنظرية لمتوسط درجة حرارة الجدار مع وبدون درجة الحرارة العددي أعلى من الحالة التجريبية بالرغم من الفروق بين الحالتين إلا أن النتائج المقبولة حوالي 10٪.

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة الفرات الأوسط التقنية

الكلية التقنية الهندسية – النجف

تحسين انتقال الحمل الحراري بواسطة جريان الطفو المستحث في القناة الراسية

رسالة

مقدمة الى قسم الهندسة تقنيات ميكانيك القوى

كجزء من متطلبات نيل درجة شهادة الماجستير في تقنيات الحراريات

في الهندسة تقنيات ميكانيك القوى

تقدم بها

ولاء علي ناجي

تقنيات هندسة تبريد وتكييف

2017

اشراف

الاستاذ الدكتور زيد معن

اكتوبر 2022